SD DEPARTMENT OF TRANSPORTATION
OFFICE OF ROAD DESIGN

CADD Procedures Manual

Section B - Design

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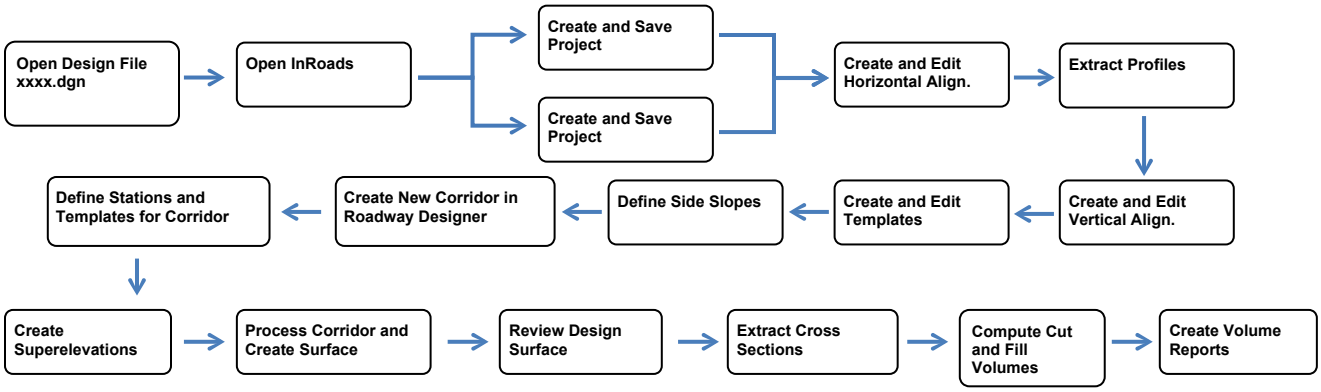
InRoads Master Workflow



Getting Started

- If the project folder has not already been created, create the folder as u:/rd/prj/COUNPCN# using Windows Explorer.
- Create a new Microstation 3D graphics file, saving it as ePCN#.dgn in the project folder. Recommend using applicable seed file NorthZoneSPC.dgn or SouthZoneSPC.dgn, which contains useful reference files such as MRM. Close file
- Click and drag Microstation to the bottom of your left screen bar <Left click> on Microstation and pin [to this list (right side)] your ePCN#.dgn. Open file F1 key to start InRoads
- Attach the topography file as a reference file from the u:\regionXX\prj\COUNPCN# folder.
- Execute MicroStation's **File** > **Save Settings** command.
- Toggle on **Pencil/Pen** and the **Delete Ink** checked
- Urban Projects Select File<Project Options> Urban preference Load <Close> <Close>

For each specific project the preference for urban, suburban or rural will need to be set in order for the design to scale properly.

Open InRoads Files

See Appendix A for instructions on creating an InRoads Project file. An InRoads Project file allows the user to simultaneously open selected InRoads design files. This file can be created at any time.

Original Ground Surface

Open the original ground DTM from the REGION folder (u:\regionXX\prj\COUNPCN#\PCN#org.dtm).

Geometry Project

- **File > New.**
- Under the *Geometry* tab select Geometry Project as the geometry type and enter ePCN# as the project name. Add pertinent information in the *Description* field.
- Save the design geometry to the corresponding project folder as (ePCN#). The save process will default to "Geometry Projects (*.alg)".

Create and Edit Horizontal Alignments

Open the geometry project (ePCN#.alg) from the project folder.

- Create Horizontal Alignment **File > New.**
- Under the *Geometry* tab select *Horizontal Alignment* as the Geometry *Type*, enter mainline as the alignment *Name,* select mainline for the *Style* and the *Curve Definition* should be set to Arc. Add pertinent information in the description window. Note, all alignments should have the style set to mainline. Also, the default style is the same as the mainline style.

See CADD procedures Section A regarding proper naming convention for non-mainline alignments.

Create PI's – There are three separate and independent methods for creating horizontal alignments:

- **Geometry > Horizontal Curve Set > Add PI –** Identify points for PI's using graphics and/or key-ins. (Example key-ins: ne = northing & easting coordinates; di = distance & direction). Note: This is the typical method that is used.
- **Geometry > Horizontal Elements**
- **Geometry > Utilities > Create/Edit Alignment by COGO Points –** The COGO point names must be numeric.
- The PI's can be displayed by using **Geometry > View Geometry > Horizontal Annotation**, and toggling on *Display Points I Off-Alignment***.**

Computations are planer even if the horizontal alignment includes several different elevations.

Add Horizontal Curves (Horizontal Curve Set method)

- **Geometry > Horizontal Curve Set >Define Curve**
- Move from PI to PI by selecting *Next* or *Previous* at the bottom of the dialog box until the desired curve set is highlighted. Fill in the *Horizontal Curve* portion of the dialog box. For simple curves, the *Curve Set Type* = SCS. Enter desired curve radius (*Radius 1*). The *Leading* & *Trailing* Radii for simple curves = 0.

To eliminate a short tangent between Horizontal Curves (two different options):

1. **Floating Curve**

- Turn off Accusnap
- Lay out Horizontal PI's as described above.
- **Geometry > Horizontal Element > Add Floating Curve**
- Set *Mode* to *Point & Direction*. Be sure the *Point* checkbox is toggled on.
- Create the 1st Horizontal Curve.
  - Select the *Point* target and snap to the PRC (midpoint of the ahead tangent is a good place to snap to, but any point along that tangent will work).
  - Select the *Direction* target and identify the direction of the ahead tangent of the 1st curve.
  - Select <Apply> and select the back tangent (somewhere near the PI) of the 1st curve. Data point to accept.
- Create the 2nd Horizontal Curve.
  Select the ahead tangent (somewhere near the PI) of the 2nd curve. Data point to accept.
- Delete the middle tangent.
  - **Geometry > Horizontal Element > Delete Element**
  - Set *Inclusion Mode* to *Selected Element Only*.
  - Select <Apply> and select the middle tangent. Data point to accept.

Note: The Middle Tangent Direction remains the same in this option. The horizontal curve radii are based upon the location of the PRC that is selected.

2. **Free Curve**

- Turn off Accusnap
- Lay out Horizontal PI's as described above.
- Select desired radius for 1st Horizontal Curve. (Geometry > Horizontal Curve Set >Define Curve & Apply)
- **Geometry > Horizontal Element > Add Free Curve**
- Enter desired radius for 2nd Horizontal Curve.
  - NOTE: If you need your 2nd Horizontal Curve to curve to the left (CCW), you need to enter the desired radius with a negative (-) symbol in front of the radius value.
- Make sure the box to Delete Existing Elements Between First and Second is checked
- Click Apply
- You will be prompted to Identify 1st Element – Select the 1st Horizontal Curve
- You will then be prompted to Identify 2nd Element – Select the Ahead Tangent of the 2nd Horizontal Curve
- Data Point to Accept

SAVE !! When the information is worth saving – Save It.

Review the Horizontal Alignment

- **Geometry > Review Horizontal**,

Annotating the Horizontal Alignment

- To annotate the Bearings, PC's, PT's and ends of the alignment:
  - **Geometry > View Geometry > Horizontal Annotation**
  - Set *Apply Style* to Assigned (as set when alignment was created) or Active (Style set will override the Style assigned to the alignment).
  - Select the appropriate *Preference* for the type of project being designed.
  - Enter the alignment to be annotated. Toggle on *Display Points / On-Alignment* and <Apply>.
- Stationing:
  - **Geometry > View Geometry > Stationing**
  - Select the appropriate *Preference* for the type of project being designed.
  - Under the *General Tab*, select the *Horizontal Alignment* to be stationed and <Apply>.
- PI curve data:
  - **Geometry > View Geometry > Curve Set Annotation**
  - Select the appropriate *Preference* for the type of project being designed.
  - Under the *General Tab*, Select the *Horizontal Alignment* to be annotated and <Apply>.

In general, for reconstruction projects the beginning station of horizontal alignments should be 0+00. The work should begin at 10+00 for all scales. This allows for work to begin previous to 10+00, if needed, without changing the stationing of the design data and notes.

Setting the beginning station to the necessary "begin station" can be accomplished by the following:

- **Geometry > Horizontal Curve Set > Stationing**
- Select the *Horizontal Alignment*
- Enter the desired starting station in the *Starting Station* and <Apply>.

Horizontal & Vertical Alignment Coordination

- **Geometry > Horizontal Curve Set > Stationing**
- Note – Prior to performing any of the following, save a copy of your current information.
- Within this dialog box there are choices under *Vertical and Superelevation Alignments*.
- *Do Not Update* – If you add 1,000' to the Horizontal Alignment Stationing, the Vertical Alignment Stationing will not change.
- *Synchronize Starting Stations* – If you add 1,000' to the Horizontal Alignment Stationing such that the Begin station is 110+00, the Begin Station of the Vertical Alignment will be changed to match the Horizontal at 110+00 regardless of what it was previously.
- *Maintain Station Difference* – If you add 1,000' to the Horizontal Alignment Stationing, 1,000' will be added to the Vertical Alignment Stationing. Typically, this is what we would utilize.

Horizontal Station Equations

- **Geometry > Horizontal Curve Set > Stationing**
- Select "New" at the bottom of the dialog box.
- Enter the Back and Ahead Stations for the equation and enter <Apply>.
- For "Overlap" equations, the Ahead Station will require an "a" in front of the station. For subsequent "Overlap" equations, you will need to continue with "b", etc.

Adding Horizontal Event Points (Pipe, Entrance, and other desired special cross sections)

- **Geometry > Horizontal Curve Set > Events**
- Define by: Single Station
- Add As: Station and Offset
- Locate By: Enter the desired Station (Offset = 0) and <Apply>.
- Event point stations can be edited within this dialog box.

Note – If the horizontal alignment stationing is changed, horizontal event points do not update. They remain at the Station that they were set at. They can be edited individually as noted above.

It is very important that all the points defining the Horizontal Alignment be at the same elevation (1500.00). If all the same elevations are not used, the plan sheets may be cut incorrectly. Review the horizontal alignment - **Geometry > Review Geometry Points >** *Report***.**

If the alignment points are on different elevations, they can all be moved to one elevation by choosing "All Points" under "Mode", typing the desired elevation and <Apply>.

Horizontal Alignment Reports. You can create reports to review your alignment.

- **Tools > XML Reports > Geometry**
- *S*elect *Horizontal Alignment* and <Apply> .
- Numerous .xml Report options are generated. Some will be partially or completely blank due to a lack of input data. Select desired .xml Report and Review.
- To save a hard copy of any report, highlight desired .xml Report. **File > Save As >** Select Word Document format (.doc) and save to appropriate directory.

Alternatively, you can create a report by selecting **Geometry > Review Horizontal >** This report can be saved to a hard copy similar to that described above. **File Save As >** Select Notepad format (.txt) and save to appropriate directory.

Extract Profiles

The purpose of this process is to create a profile for displaying the existing ground profile, and from which the new grade line may be established.

- Open the geometry project file and set active the appropriate horizontal alignment.
- Open and set active the original ground dtm (PCN#org.dtm) from the respective region project folder.

Before creating the existing ground profile, verify the existing ground elevation limits (**Surface > Surface Properties**) and adjust the profile limits accordingly to allow for the display of design vertical PI's.

- Set **Station Lock** to ON.
- **Evaluation > Profile > Create Profile**
- Select the appropriate *Preference* for the type of project being designed (appr_pipe, Rural, Storm, Suburban, Urban).
- Under the *General* leaf/*Surfaces* toggle on the PCN#org surface.
- Under the *Source* leaf/*Alignment* select the active horizontal alignment (this will draw the original ground along the active horizontal alignment).
- Under the *Controls* leaf enter the minimum and maximum elevation limits as explained above. Likewise, *Station* Start and Stop limits should be entered at this time as necessary.
- **<Apply>** and then place a Data point to locate the lower left-hand corner of the profile. The profile grid will be generated with the execution of the **Create Profile** command.

Create and Edit Vertical Alignments

Open the geometry project (ePCN#.alg) from the project folder.

- Set the Horizontal Alignment to mainline.
- **File > New.**
- Under the *Geometry* tab select Vertical Alignment as the geometry type and enter mainline as the alignment name. Add pertinent information in the description window.
- Graphically lay out vertical alignment PI's
- **Geometry > Vertical Curve Set > Add PI**
- PI's can also be added by keying in station and elevation using **se=** (station and elevation)

View Alignment

Geometry > View Geometry > Active Vertical

Add vertical curves

- **Geometry > Vertical Curve Set > Define Curve**
- Identify the vertical PI by clicking <Next> until the desired PI is highlighted.
- Enter vertical curve length in **Length** field
- <Apply >

SAVE !! When the information is worth saving – Save It.

Before exporting/importing horizontal and vertical alignments, change all curve lengths to 0 feet. This will allow the alignment to be defined with PI's rather than components.

Vertical Alignment Reports

- **Tools > XML Reports > Geometry**
- Create the vertical alignment report following the same procedure as outlined above for horizontal alignments, substituting vertical for horizontal.

There are different methods to get the templates and roadway designed for your specific project.

Copy Templates

Create a new Template Library

- **Modeler>Create Template**
- In the **Create Template** box, select **File > New Template Library**
- In the **Save As** box, key in (PCN#.itl)
- Select **Save**

Copy Standard Typicals

- In the **Create template** box, select **Tools>Template Library Organizer**
- In the Organizer box's **Available In** section, select the **Browse (…)** button and browse to U:\rd\Bentley\V8i\Inroads\data\English\SDDOT.itl then select **Open**
- Expand the directory tree on the right side
- Drag and drop folders or individual templates as desired from the right side (…SDDOT.itl) to the left side (…PCN#.itl)copy from
- Select **OK**
- When prompted to save data, select **Yes**

The template will need to be adjusted to match the design summary. Make the necessary modifications to lane, shoulder, subgrade widths and undercut depths, etc. Refer to **Editing Templates.**

Editing Templates

Note: Templates can be modified in both the .itl and the .ird files. The preferred method is to modify them in the .itl file. If templates are modified in the .ird file they cannot be synchronized with the .itl anymore without losing the edits made to the .ird.

- <Double Click> u:\rd\prj\COUNPCN#\PCN#.itl in the Create Template box, the tree view, select desired Roadway Templates or Typical Sections.

You can either select typical sections which already have the end conditions attached or select roadway templates and then add the desired end conditions.

- Notice the selected template is displayed in the view on the right
- To add end conditions to a roadway template in the Create Template box, the tree view, Template Library <Click> desired end condition drag (but before releasing it) right-mouse click to access the mirror option, then place on the desired roadway template.
- <Double Click> on each end condition Component Properties **Target Type** Surface **Surface** PCN#org

You may choose to delete end conditions, roadway templates or typical sections that do not pertain to your project. You may also choose to copy and paste the roadway templates with end conditions into the typical sections folder. There is no right way or wrong way to achieve the roadway typical section.

The software has options to edit templates. Refer below

Option 1

- Create Template box, data your roadway typical section and in the view on the right displays the components, (Horizontal, Vertical and Slope) parametric constraints, etc.
- Display Box <Constraints button on> and Display Point Names checked to help make the necessary changes.
- Increase your view and move cursor on the drawing in the cross section view and a box will indicate if it is a point or a component with other information. To edit lengths of constraints to match your design summary <double click> on red plus signs or move cursor to the red plus sign and <right click> and <click>**edit point** then change the desired parameters in the **Point Properties**
- Select previous or next to move within the template in the **Point Properties**
- You may need to delete, move or add constraints for your specific project.
- To add a finished surface in the urban design <right click> on your starting point add new component, constrained, move cursor in direction up from subgrade connect the area component with points <right click> and finish. Design Constraints from your subgrade line <double click>(new point) change horizontal value to 0.00 under constraint 1 and vertical value to surface thickness under constraint 2. Label as Lane, Surface Feature Style as Finish, Member of Finish. Complete constraints for all new points within the finish component
- Verify Template Origin is correct in relation to your vertical alignment
- For Surfaces **Finished** and **Undercut** In Component Properties check mark **Exclude from Triangulation**

Verify all point properties are designed correctly for your project with respect to parent names, slopes, values, constraints, components, etc.

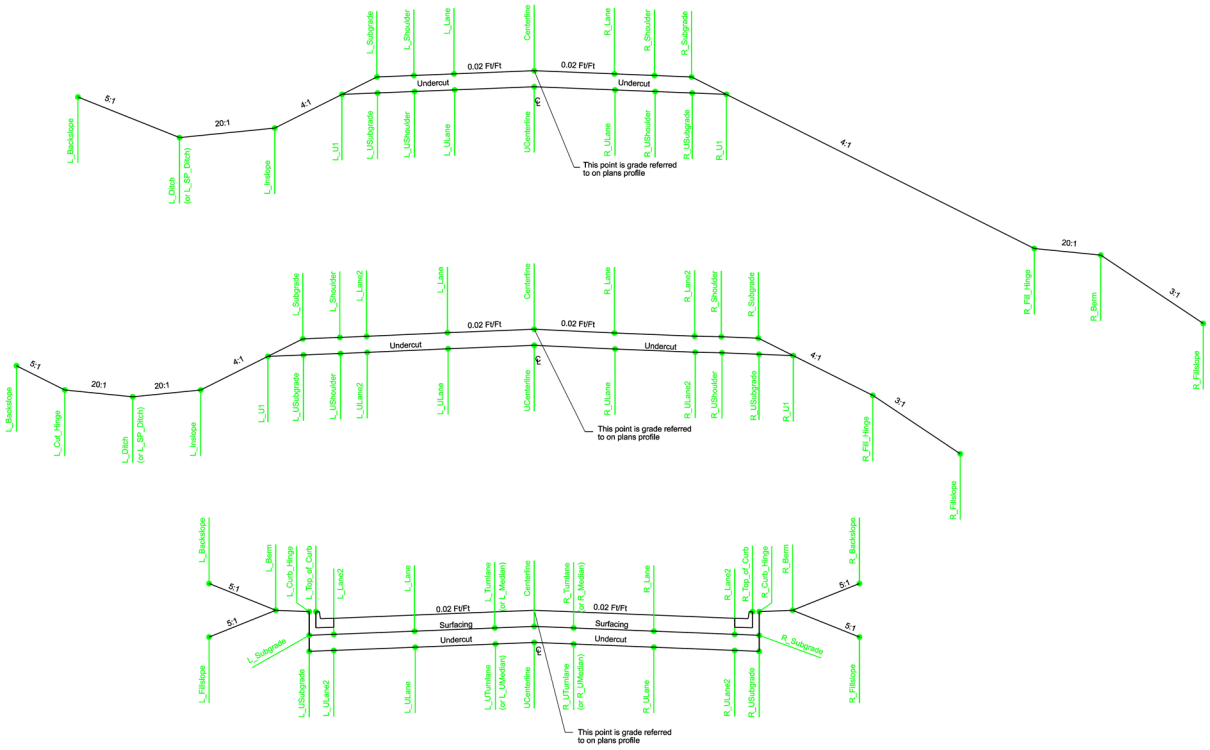
A mainline template may include the standard mainline components, finish, subgrade and undercut. See CADD procedures Section A regarding proper naming convention for non-mainline Layers.

- **When the creation of the Roadway Typical Section is complete, save the Template Library, File save as PCN#.itl.**

- Close

Option 2

- **Modeler > Roadway Designer**
- **Tools > Parametric Constraints** Constraint Label drop down box for lane, left shoulder, right shoulder, sidewalk, subgrade and undercut. For each label activate the start and stop station with the start and stop value. <Add> [example: the constraint label **Lane** from station to station is 12' then all lanes left and right will be shown as 12').
- Close
- Each point in the template is named with a **Surface Feature Style**, **Constraints 1 & 2 with Parent** and **values**. Point Properties for Cut and Fill Slopes have additional **End Condition Properties.** (Example: the segment to the right of centerline on the rural template is "R_Lane" - See Example: rural that follows). These Point Properties are to be left as they are unless it is deemed necessary to change them.



- Point Property names should remain consistent for transitioning from one template to another.

- To edit lengths of components to match your design summary use Point Properties for defining the roadway section beyond the subgrade limits. This can define standard cut and fill sections as well as urban cut and fill sections. It is flexible in that any number of situations can be coded into a particular Template to define special criteria such as a special ditch or flatter than standard fill slope.

Create a Roadway

Create a Roadway as follows:

- **Modeler > Roadway Designer**
- **Corridor** > **Corridor Management**
- **Manage Corridors** Name *mainline*, Surface Symbology *mainline,* Type *alignment*, Horizontal alignment *mainline*, Vertical Alignment *mainline* Limits *Toggle Station start and stop* if desired < *Add*> A project must have one corridor to create a valid design from which a surface can be created. Notice you can add, copy, change or delete corridors from your design at any time.<Close>
- Save the Roadway Designer to the corresponding project folder as (PCN#). The file save as process will default to " Roadway Design (*.ird)".
- Notice that you can also directly open a PCN#.ird file using **File**>**Open** in Roadway Designer.

- The top-left window is the plan view and displays the alignment (mainline) of the active corridor in light blue. The active surface perimeter is shown as white (Lock Active Surface to PCN#org), the current station location is shown as the yellow line. The bottom–left window is the profile view. The large top-right window is the cross-section view.

Dropping Templates in the Corridor

- **Corridor > Template Drops**
- Template drops comprise a series of points and components that represent breakline features that are processed using the Roadway Designer command. A component is a set of points that define an open or closed shape. Each component, whether open or closed, can represent a different material or area of interest. Components are named and have an assigned style. There are 5 types of components created in InRoads*: Simple, Constrained, Unconstrained, Null point, and End Condition*. For more specific details on components, see the **Create Template Overview** help topic.
- *Library Templates* box <Browse>button to find u:\rd\prj\COUNPCN#\PCN#.itl. Select Corridor *mainline,* In the *Station* field, enter station where the desired template will begin. In the *Interval* field, input the interval by which InRoads will "drop" a template for modeling (*typically 50 feet for rural and/or urban projects).*
- <Double Click> u:\rd\prj\COUNPCN#\PCN#.itl in the Library Templates box, the tree view, select desired Roadway Templates or Typical Sections then <Add>.
- Notice the selected template is displayed in the view on the right, and is added to the Current Template Drops list at the bottom of the dialog box.

If a template needs to be modified at a later time you can do this by editing the template in the template library (.itl). Once the template has been modified in the template library it will need to be synchronized in the template drops dialog box. The templates used in the template drops will appear red indicating that the .ird file does not match what is in the template library. Once this is synchronized, the template drop will appear black again. It is preferred that the templates in the template drops dialog box be synchronized with the template library as much as possible. Any edits done to the template drops themselves will be lost once the template drops are synchronized again.

Add a new template for each change in shrink value (Enter appropriate shrink value for each undercut based on specified station ranges. In order to have different shrinkage values for the undercut, the undercut component name such as Undercut 30%, Undercut 40% and symbology such as UndercutA, UndercutB will need to be changed for each shrink value.)

Complete your Current Template Drops with each station, interval and template to match your design summary. Basically like the old Roadway Modeler run within the Roadway Library.

Once you have closed the template drops box. In the plan view, notice the visual cues (Brown Lines) that show the location of the each new template drop. In cross section the templates are displayed.

When the creation of the Roadway is complete, save the Roadway Corridor and File save as PCN#.ird.

Special Ditches

Special Ditches are ditches whose grade line does not parallel the roadway grade line. When special ditches are required, additional vertical alignments need to be created under the appropriate horizontal alignment. InRoads<Tools> Application add-ins <Click> Horizontal and Vertical Elements Add-In

- Create the vertical alignments **special ditch left** and/or **special ditch right** using the steps outlined above for creating vertical alignments.
- Set the newly created special ditch alignment active.
- **Geometry > Vertical Element > Add Fixed Line…**
- Set *Mode* to *By Two Points.*
- Toggle on each of the two *Station / Elevation* sets.
- Fill in the desired station and elevation for each segment, verifying that the stations are 0.1' before the desired beginning station and 0.1' after the desired ending station.
- <Apply> and data to accept.
- Repeat as necessary to complete the special ditch vertical alignment.
- **Geometry > Vertical Element > Check Integrity** must be executed to verify that any added vertical elements are in the correct order, by station.

The template library component has a special ditch to be searched. If a special ditch alignment is not found, the component will go to the next component entry, which is a standard or sloped ditch, followed by components for a fill section. In doing this, a special ditch can be created without changing the components each time. **Corridor > Template Drops** <Double click> on template in the current template drops box which opens up **Editing Roadway Designer Template Drop.** Template Library bottom tab make Active Template, in the network tree you can data on the components (Example: <Double Click> R_Special Ditch 1 which is the right special ditch and it will highlight **Component Properties**) Verify **End Condition Properties** as Target type *alignment elevation* Horizontal Alignment *mainline* Vertical Alignment *special ditch right* and offsets vertical *0.70*. Complete for left side L_Special Ditch 1.

- The special ditch vertical alignments must be fully created prior to creating a surface.

When the creation of the Roadway is complete, save the Roadway Corridor and File save as PCN#.ird.

Editing Between Transitions: From 2 to 4 Lane

The edit transition command allows you to interactively modify existing backbone transitions between two template drops. The backbone is considered to be the component of the template that is not an end condition or child component. The Roadway Designer makes connections based on matching point names between transition templates and then allows you to adjust it as desired.

- The **Roadway Designer>Tools>Options>Display Transition Graphics** option must be turned on to view transition graphics.
- **Roadway Designer Corridor** Mainline **Active Surface** PCN#org right bottom, select the **Process All** button. This action processes all stations of the corridor and updates all the display windows with the results. Close the Results dialog. A brown bar appears at a template drop station. Notice a yellow shape between two template drops. This shape represents a transition region (shifting from 2 lanes to 4 lanes). The yellow indicates that some, but not all, of the points have been connected and you have not yet reviewed the transition.
- **<Double Click>** anywhere on the yellow shape. In this 3D view of the backbone transition, notice that the thick red points symbols (+) are points that have not been connected to a point at the other end of the transition. Move the template to get a better view of how the points are connected. To move a template, right click over one of the template points and select the **Move Template** command. Notice how you can pause the mouse over a point to display the point name.

- To add a transition connection, left mouse click over the point (you must connect from the "unconnected" to the "connected"). Multiple points can connect to a single point. If you make a mistake or want to change connectivity, right click over the transition and select **Delete** Click **OK** on the Edit Transition dialog. Click **OK** on the reminder box that notifies the user to delete the appropriate constraints in order for the transitions to work properly. In this cross section view all of the features are shown in a cross section view. Each point shows the constraints as they were set up in the original template library. Right click on the points that need to be transitioned and delete the appropriate constraint. A transition slider bar along the bottom of the window will show how the transition is being performed over the given station range. In the roadway Designer dialog box, notice the yellow area in the transition is now dark blue. This indicates that all points of the transition are connected. Transitions should be verified as needed.
- **Roadway Designer Corridor** Mainline **Active Surface** PCN#org right bottom, select the **Process All** button. Other visual cues for transitions are red, indicating none of the points are connected, light blue, indicating the transition has been reviewed or edited, however, one or more points remain unconnected.

When the creation of the Roadway is complete, save the Roadway Designer and File save as PCN#.ird.

Roadway Designer Right click in the cross section box and select **Display Properties.** Select the settings you prefer and click **OK**

When working with templates and superelevation dialog boxes, it may be desirable to set the slope format to 0.50 so cross slopes read as 0.02 versus 50%.

- **File > Project Options**
- Select the *Units and Format* tab.
- Under *Format* Select the *Slope* drop down menu and select 0.50.

- <Apply> <Close>

Superelevation

Superelevation is used to control the cross slope of roadways in areas of horizontal curves. In roadway designer superelevation control lines can be created and then used as vertical point controls to control the elevation of a point relative to another point in the cross section.

Modeler > Roadway Designer

- In the bottom right corner, toggle on **Superelevation** display mode. The superelevation diagram is synchronized to display the same station range as the profile view. The plan, profile, and cross section view now show cross slope values of the backbone of the template. (Hot) Colors from yellow to red indicate increasing slope from left to right. (Cold) Colors from green to blue indicate increasing slope from right to left. White indicates a cross slope at or near 0%. A typical normal crown section is Yellow / Orange on the Left and Green / Blue on the Right.

Superelevation > Create Superelevation Wizard > Table

- <Browse> from *Table Wizard* to find C:\dot\rd\data\06sd__.sup. Open the *Rate Table* that corresponds with the design speed as defined in the scope document.

- Toggle on *Percent Total on Tangent* and set to 80%. Transition Lengths Are: Toggle *Total Transition.* Select *Load Values from Table* in Selected Curves Tab (Click on the box to load the values). *Select* **<Next>**
- In the *Superelevation Section Definitions* dialog box, Select *Add* under *Sections* to add a section to be superelevated.
- In the Add Superelevation Section dialog box, Crown Point: select Centerline, Left Range Point: select L_Subgrade (or urban section use point along front of gutter so the segment under the c&g does not superelevate), and Right Range Point: select R_Subgrade (or urban section use similar as discussed above for the left side). Pivot Direction: From Crown Point (for Two Lane Roadway or where applicable). Number of lanes: Toggle Two. Runoff Length Multiplication Factor: 1 (or number from RD Manual if more than 1 lane to be rotated). Station Limits can be left toggled off to cover the entire horizontal alignment. Select <OK>.
- In the Superelevation Section Definitions dialog box, to view the basic superelevation information for each curve, highlight the curve under Superelevation for Selected Section and Select Edit. Select <Close> to exit.
- Back in the Superelevation Section Definitions dialog box, Select <Next> to proceed.
- The Superelevation Controls dialog box shows the final superelevation controls that have been created. Select <Finish>
- The superelevation wizard completed the design task of creating control lines for each point to be superelevated.

If you need to model superelevation which does not follow the standard tables, keep in mind that creating your own table specific to your projects parameters is an option.

The superelevation process will need to be repeated if the horizontal alignment is modified or restationed after the completion of superelevation.

SAVE !! When the information is worth saving – Save It.

Import Superelevation from ASCII is another method available to model superelevation using the following steps. This method is simple and useful where the desired superelevation does not follow standard tables and needs to be input manually.

Create ASCII file

- Create *.txt file in Notepad with each line having the following format.
- Station (tab) Left Grade (tab) Right Grade
- Grades are in ft/ft with positive and negative values based on direction from the crown point.

Modeler > Roadway Designer > Superelevation > Import Superelevation from ASCII

- File: <Browse> to *.txt file created above.
- Section: Input “1” for the first curve, “2” for the second, etc.
- Select Crown Point, Left Range Point and Right Range Point (See Note below)
- Apply
- Note: It appears this method does not apply the superelevation to all the points between the crown and the range points, therefore, the *.txt file must be applied to all the points that need to be superelevated. For a typical rural 2 lane road the ASCII file needs to be imported 3 times by changing the range points to do the lanes, then shoulders, then subgrades.

Editing Superelevation

Modeler > Roadway Designer > Display Mode: Toggle on **Superelevation**

In the bottom right window of the Roadway Designer,

- Right click on point, Select Edit Point, Select Subgrade
- Superelevation Point Properties: Edit station and cross slope or others as needed.
- Repeat for all the points that need to be edited. May also need to change points at the same location as Subgrade, such as Lane and Shoulder, etc. Verify in the view.

OR

- Right click in bottom right window
- Select Edit Curve Set Stations
- Edit stations and cross slopes. Toggle off Constrained where needed to change items.
- This method of editing cannot do all the points so the above method needs to be used to finish the editing.

Deleting Superelevation

Modeler > Roadway Designer > Corridor > Point Controls

- Select the control(s) from the table
- Select Delete in the bottom right corner

Modeler > Roadway Designer > Display Mode: Toggle on **Superelevation**

In the bottom right window of the Roadway Designer,

- Right click control line, Delete Control Line
- Repeat for all control lines to delete.

Superelevation > Apply Shoulder Rollover Lock

This section is a work in progress. After one or more individuals has had a chance to work on a rural divided roadway with superelevation, the design process for this section will be updated and the template points will be updated with correct terminology. The process written below was written for a two lane roadway with the Range Points set at the edge of the driving lanes.

For Two Lane roadways, Shoulder Rollover Lock should typically not be necessary. For Four Lane roadways, it may be necessary to utilize this design tool so that the entire subgrade surface rotates as necessary in superelevated sections.

Shoulder Point: LOS Set Difference for both High Side and Low Side to 0. Toggle on Match Transition Slope. Leave the High Side Maximum Slope and Low Side Minimum Slope toggled off. <Apply> Repeat the process for Shoulder Point: ROS. <Apply> again. <Close> the dialog box.

- **Process All**

- **Modeler > Roadway Designer > Superelevation > Superelevation Report** Report At: Toggle All Processed Stations. Select All Available Superelevated Points (LEP, LOS, REP, ROS). <Apply> Review data to verify accuracy.

- Note: For the LOS & ROS, the high side shoulder begins rotating prior to the driving lane (from 4% to 2%) to match the slope of the driving lane. This rotation occurs prior to the calculated beginning station of the superelevation based upon the rate of change for the curve. For example: 70 mph design speed, 4.0% superelevation rate, transition length = 180'. The 2.0% shoulder change would occur over 60' = (.02 / .06) x 180'. This transition would occur within the 60' prior to the typical Begin Superelevation Station.

Note: For the LOS & ROS, the low side shoulder holds at 4.0% until the inside driving lane has rotated to a point where it is also 4.0%. For the example listed above, the low side shoulder would not rotate at all since the superelevation rate for the curve is 4.0%.

Defining End Condition Exceptions

End condition exception is an efficient method of modifying the behavior of an end condition solution without making additional template drops.

- **Roadway Designer** bottom right corner toggle on **Normal** display mode**. Corridor< End Condition Exceptions**
- Select Station Range start and stop Apply to Override or Transitions **<Add>**
- Highlight the new entry, select **Edit** or <**Double Click>,** the Create Template command is activated to an Override box
- Move cursor to the point you want to override and right click to move point, delete, etc. however you want to change that point. <Click> **OK** in Override box & **Close** to End Condition Exceptions

SAVE !! When the information is worth saving – Save It.

Parametric Constraints

Parametric Constraints allow for flexibility to vary a specific constraint on a point without creating additional templates. These are useful when adjustments need to be made for a short stretch such as a right turn lane or left turn lane in a median section. Another great use of this is the ability to increase the surfacing thickness quickly instead of having to change the template which may result in changing multiple templates. This saves time overall and can be adjusted as necessary.

To set up a Parametric Constraint, the first thing that will be needed will be to have needed constraints labeled inside your template. Once this is done, different parametric constraints can be added:

- **Modeler>Roadway Designer**
- *Tools* > *Template Library* or click on Template Library button
- Select the appropriate template
- Edit the point that needs to have a parametric constraint added
- Under Constraint 1 or Constraint 2 there is a box for *Label*: Type a logical name here such as Lane or Finish depending on the constraint being labeled. You will need to reference this name in a future step
- Click <Apply>
- Make sure to save your Template Library before you exit the *Create Template* screen
- Select the appropriate corridor
- You will also need to make sure that your template drops are synchronized with your Template Library so the constraint labels show up
- Now still in Roadway Designer select *Tools* > *Parametric Constraints*
- Select the appropriate Constraint label from the drop down box
- Input the start and stop station limits that the parametric constraint is taking place over
- Input the Start Value and Stop Value which is referenced from the point that the label was made from inside the template. For example: A 12’ wide lane from the template may be widened out to a 24’ lane for a right turn lane. The Start value would be 12’ and the Stop Value would be 24’. For the left side of the template a negative value is needed.
- Click <Add>
- Repeat this process as needed

SAVE !! When the information is worth saving – Save It.

Point Controls

Point Controls allows for the flexibility to model a roadway with varying geometry, without creating additional templates. Point controls are similar to Parametric Constraints in that it can allow a point name from the template to be altered from the standard template. Where they differ is that when using Point Controls the point will follow a horizontal alignment, vertical alignment or both over a set station limit. This is useful if a point in the ditch would need to follow a certain alignment that may differ from the mainline alignment. It could also be used for a lane point to follow a curve that differs from the rest of the mainline. There are many uses for Point Controls and is a powerful tool.

To set up a Point Control:

- Set the appropriate horizontal and vertical alignments active.
- **Modeler>Roadway Designer**
- Select the appropriate corridor
- *Corridor* > *Point Controls* or click the Point Controls button
- Select the appropriate point name (the point that is to vary to meet the needs of the geometry).
- Toggle the desired mode (Horizontal, Vertical, or Both)
- Drop down the Control Type to use: Alignment, Feature, Style, or Corridor Point (In most cases Alignment will be used)
- Select the appropriate *Horizontal Alignment* (this will be other than the active horizontal alignment if a separate alignment has been created for the sole purpose of utilizing Horizontal Control). If the Mode is seeking a vertical alignment than choose the Vertical alignment as well.
- Input the appropriate *Station Limits / Start* and *Stop* stationing.
- Input the appropriate *Offsets* if needed. This will be the offsets from the alignment that the point is seeking, not the mainline alignment.
- <Add>
- Repeat the process as necessary for each additional entry.

Note: If you have superelevation applied to the corridor already then those superelevated points will show up in the list here as well. Scroll down to see your newly added point control. You can also click on the point control you created and edit them.

SAVE !! When the information is worth saving – Save It.

Creating the New Surface

Typically, the end result in the Roadway Designer is the generation of a new design surface form which plan, profile, and cross section drawings are created. Using the **Corridor< Create Surface** command

- **Roadway Designer** **Corridor** *Mainline* **Active Surface** PCN#org
- **Create Surface** dialog box Create surface from *Mainline*
- Click **<Apply>** then **<Close>** Results dialog and the Create Surface **<Close>** Roadway Designer
- Save surface *Mainline* Review your surface *mainline*

If you need to save the display of triangles or contours, create a separate graphics file (cPCN#.dgn), which can then be attached as a reference file as needed.

- **Surface > View Surface > Contours**
- Select the appropriate *Surface*.
- For large projects, establish a fence and set *Fence Mode* to the appropriate setting. The fence must be established prior to executing the View Surface command.
- Set *Interval* and *Minors per Major* to the desired settings.
- Edit the <Preferences…> and *Symbology* as needed.
- <Apply>

And/or

Surface > View Surface > Triangles
Select the appropriate *Surface, Fence Mode, Symbology* and <Preferences…>.

If a surface is viewed temporarily in a file, delete contours or triangles when done and compress the graphics file.
The fence mode is useful for large projects because it can limit the contours or triangles to an area inside the fence.

Feature

The two most common uses for Features is for annotating cross sections and for attaching cells (such as the curb & gutter cells) to cross sections.

As directed earlier in the Create Cross Sections section of this document, toggle *Include Features* off when creating a cross section set. If it is desirable to include the features, generally only the subgrade features that represent the exterior boundary, special ditch elevations, and curb and gutter features need to be turned on. It is good practice to keep the number of features displayed in the cross sections to a minimum as displaying features can cause the file to become very large.

To attach cells to features

- **Tools > Named Symbology Manager**
- Select the appropriate feature code from the list displayed in the dialog box.
- <Edit>
- Select *Cross Section Point*.
- <Edit>
- Set *Display As* to *Cell*.
- Set *Level* to the appropriate level.
- Set *Cell Name* to the appropriate cell to be associated with the feature code.

The proper cell library must be attached to the MicroStation design file prior to executing the Symbology Manager command.

- Verify that *X Scale, Y Scale* and *Z Scale* are properly set. Some cells require that the *Y Scale* be set to 0.50, while the other scales remain at 1.00.
- <OK>
- <Apply> and <Close>
- <Close>

These cells will now be displayed with the corresponding feature code, when the feature codes are displayed in the cross section set.

Cells associated with feature codes will be removed or added from the display in the cross section set, as their parent feature code is removed or added.

Create Cross Sections

Cross sections will be drawn in a separate graphics file (xPCN#.dgn).

- **Surface > Surface Properties…**
- Select the *Advanced* tab.
  - Select the appropriate *Surface.*
  - Select the corresponding *Cross Sections Symbology.*
  - Select the corresponding *Profiles Symbology* (this will be useful when creating approach pipe sections).
- <Apply>

Two separate cross section sets will be created for two separate purposes:

1. The Plans Cross Section Set – This set will be created for plotting and will include annotation and a plans border. The Undercut surface will not be displayed in this set of cross sections unless requested by the Area Office.
2. The Volume Cross Section Set – This set must show the entire range of cross sections and all surfaces necessary for volume computations. The actual earthwork volumes are calculated from the elements created for each surface in the graphics file.

Open the original ground surface (PCN#org.dtm), the geometry (ePCN#.alg) and the appropriate design surface (Mainline)

- **Evaluation > Cross Section > Cross Sections…**
- Open the *Create Cross Section* Folder.
- <Preferences…>
  - Plans Cross Section Set – Set the appropriate preferences to 10_20_portrait, 20_40_portrait, 10_20_landscape or 20_40_landscape.
  - Volume Cross Sections Set – Set the preference to *volumes*
- Open the folder *Create Cross Section*.
  - Under General
    - *Set Name* will default to the horizontal alignment name, and will change by an increment of 1 (mainline_1, mainline_2, etc.) for each subsequent cross section set created. Modify this entry to (volume) for the Volume Cross Section Set.
    - Open the *Source* subfolder turn on *Alignment* and select the appropriate horizontal alignment.
  - Under Controls
    - Modify the *Limits* settings as needed. (The *Station* limits will be ignored if entries are created under the *Custom* tab).

- See Cross Section Reports later in this document for details on creating a cross section report during the Create Cross Sections process.

- Return to the *Main* tab.
- <Apply> and data point a position in the graphics file.

- **The cross section *Interval* must be at the same interval (or multiple of interval) that the template was dropped. If it is not, the design surface may not tie to the original ground on the cross sections. The cross section Interval shall be set to 100.00 feet for rural projects and to 50.00 feet for urban projects or mountainous terrain.**

Cross-Section Viewer

- **Evaluation > Cross Section > Cross Section Viewer**
- Select the appropriate *Cross Section Set.* A fence with the active MicroStation properties will display around the selected cross section set.
- Modify the *Zoom Factor* as needed.
- <Run> and data the appropriate view (*ESC* to stop the display while running).

Update Cross Sections

This command allows the user to update the surface graphical elements following the execution of the Roadway Modeler command, without having to recreate cross sections.

Features must first be removed from the cross section set before surfaces are refreshed. To remove features, follow the steps listed below, selecting *Display Off* instead of *Refresh* and the appropriate features listed in the *Object / Feature* window in conjunction with the appropriate surface.

- **Evaluation > Cross Section > Cross Sections**
- Select the appropriate *Cross Section Set.*
- Open the *Update Cross Section* Folder.
    - Under *General*
        - Toggle on *Refresh* to update the surface graphical elements.
        - Set *Limits / Station Range* as needed.
    - Under *Surfaces*
        - Select the appropriate surfaces.
- <Apply>

This command is also used to toggle on or off features for annotating the cross sections.

Annotating Cross Sections

- **Evaluation > Cross Section > Cross Sections…**
- Select the appropriate *Cross Section Set.*
- Open the Update Cross Section folder.
    - Under General
        - Toggle the Mode:/*Display On.*
    - Open the *Crossing Features* subfolder.
        - Select the appropriate *Surface* followed by the appropriate *Features.*
- <Apply>
- Open the *Annotate Cross Section* Folder. Select Preference
    - Under *General* subfolder
        - Select the appropriate *Surfaces.*
- Open the *Features* subfolder

- Under *Annotate* (In the Features subfolder).
  - Select all features by opening *Filter*… and toggle on *Start with:/All and press* <Ok>
- <Apply> and <Close>

Exterior Boundary, Left Subgrade and Right Subgrade are annotated using the 10_20_scale or 20_40_scale preferences. Special Ditches are annotated using the Left Special Ditch and Right Special Ditch preferences. Note that the Special Ditch preferences are configured for the 20_40 scale cross section sets.

Once the cross section set has been annotated return to the Update Cross Section command, Toggle *Mode: / Display Off* and follow the remainder of the steps for displaying features outlined above to "turn off" the features. This will remove the feature graphical elements from the dgn.

Plotting Cross Sections

To plot cross sections in .pdf format follow the steps in the link below.

https://dotfiles.sd.gov/cadd/ElectronicPlans.pdf

Pipe Cross Sections

Mainline Pipe Cross Sections

Open the geometry project (ePCN#.alg) from the project folder, and set the appropriate horizontal alignment active.

- Place horizontal event points at all proposed mainline pipe locations.
  - **Geometry > Horizontal Curve Set > Events…**
  - Set *Define By:* to *Single Station.*
  - Toggle *Add As / Station and Offset*.
  - Enter the pipe station in the *Locate By / Station* field, leaving the *Offset* field set to 0.00.
  - <Apply>
  - Repeat until all pipe locations have been entered.
  - <Close>
- **Modeler > Roadway Designer…**
- Create a new surface under **Roadway Designer > Corridor > Create Surface**…
- Select the appropriate surfaces.
- <Apply>
- Create a new Microstation 3D graphics file, saving it as pPCN#.dgn in the project folder.
- **Evaluation>Cross Section>Cross Section…**
  - Set the *Preference* to 10_20_Landscape.

Hint: Under the Controls>Criticial Sections tab, turn off Horizontal Event Points

Create a separate pipe cross section set for the 20_40_Landscape preference as needed

- Open the *Create Cross Sections* folder followed by the *Custom* subfolder
- Select the *Custom* tab.
  - Select *Perpendicular* or *Skewed* as the *Type*.

- Enter the pipe *Station:* and *Skew Angle:* as appropriate as well as the *Left Offset:* and *Right Offset:* corresponding with the previously selected preference.

The *Skew Angle:* is positive for Left Hand Forward and negative for Right Hand Forward.

    - <Add>
    - Repeat until all pipe sections have been entered.
    - Save the custom pipe section set as pipe10_20.xsc (or pipe20_40), in the project folder.
- <Apply>

To delete the custom cross sections, highlight the cross section you want to delete, then hit the Delete Key.

The custom pipe section set can be recreated at any time, by loading the .xsc file from the project folder (*Control File / File Name)*.

Following the creation of the pipe cross sections, load the XPIPE MDL application to draw each individual pipe. (MicroStation Utilities > MDL Applications).

Approach Pipe Cross Sections

- Open pPCN#.dgn.
- Load the XSECT cell library and place the cell ENTL or ENTP. If you are using the ENTL cell, the station range is 320 feet. If you are using the ENTP cell, the station range is 200 feet.
- **Evaluation > Profile > Create Profile…**
- Set *Preferences* to *appr_pipe.*
    - Under *General*
        - Select the appropriate *Surfaces*.
        - Toggle *Direction / Left to Right* on for entrances on the left and *Direction / Right to Left* for entrances on the right.
        - To Set Offset: Highlight the appropriate *Surface* and select properties:
            - Set the Profiles/Symbology:
                - <Surface Properties…>
                    - Select the *Advanced* tab.
                    - Set the appropriate *Surface*.
                    - Set the appropriate *Profiles / Symbology* to Subgrade.
                    - Set the pipe *Offset / Distance* from mainline (-) for left and (+) for right.
                    - Set the *Offset / Symbology* to Appr_Pipe.
                    - <Apply>
    - Under *Controls*
        - Toggle *Station* on and select a start station that is ½ the cross section limit ahead and a stop station that is ½ the cross section limit back of the entrance location.
    - Under *Offsets*
        - Check on the appropriate *Offsets:*
- <Apply>
- Data a green point on the left side of ENTL or ENTP for an approach pipe left of mainline or data a green point on the right side of ENTL or ENTP for an approach pipe right of mainline.

Following the creation of the pipe cross sections, load the XPIPE MDL application to draw each individual pipe. (MicroStation Utilities > MDL Applications).

Compute Cut and Fill Volumes using End Area Volumes

Open the cross section file (xPCN#.dgn), the appropriate geometry (*.alg) and surface (*.dtm) files.

- **Evaluation > Cross Section >Cross Sections > End-Area Volumes Folder**
- Select the appropriate *Cross Section Set.*
- Select **General Tab** >
  - Select the *Original Surface* (PCN#.org)
  - Select the appropriate subgrade *Design Surface.*
  - Toggle Imperial Units to *Cubic Yards*.
  - Toggle Method to *Correct for Curvature.*
  - Toggle *Plot Mass Haul Diagram*.
  - Toggle *Create XML Report*. (When an End Area Volume is run a XML Report will automatically open if this options is checked.)
- Select **Classifications Tab**>
  - Set the following for all the Undercut Components.
  - *Classification> MDC*
  - *Mass Ordinate> Include*
  - *Fill Factor> Shrink value* (Enter appropriate shrink value for each undercut based on specified station ranges. In order to have different shrinkage values for the undercut, the undercut component name and symbology will need to be changed for each shrink value with names such as UndercutA, UndercutB, etc.)
  - **HINT:** The cross section set that the volumes are being calculated from should only have the undercut components displayed. Displaying other components such as the finished surface, sidewalk, etc. can cause issues with the values in the volumes report.
- Select **Compaction/Expansion Tab**>
  - *Settings> Start/Stop Stations> Station Cut/Fill Factors:* This option allows the user to input project specific shrinkage or swell.
- Select **Volume Exceptions Tab**>
  - *Settings> Start/Stop Stations>* This option allows the user to select a portion of the model, which will not be included in the volume quantity (grading exception). When using this option for excluding bridges, the start and stop stationing must be the toe of the fill slopes. *Volume Exceptions* are project specific.
- Select **Added Quantities Tab**>
  - *Settings> Start/Stop Stations> Toggle Type> Volumes & Factor>* This option must be selected to enter additional cut and fill quantities. Quantities such as borrow, muck and unstable, salvage and entrance volumes are entered here. Shrinkage values must also be entered with each added fill quantity entry. When entering quantities over a station range, enter the total quantity for the station range. Inroads adjusts this quantity per station. *Added Quantities* are project specific.
- Select **Annotation Tab**>
  - Toggle on the appropriate *Objects* as necessary to annotate the volume cross section set. This step is a user preference and is not required for calculating volumes.

Save the above end area volume settings by *File> Save As> Save in: Path to the project directory & File name: input based on the roadway alignment name*. The end area volume file should be saved as a type (*.eav) with a name that matches the alignment, such as mainline.eav or xr105.eav. This file will need to be opened to make changes to any added quantities or other settings by *File> Open*.

Added Quantities and other above settings can be edited/added by opening the (*.eav) file mentioned above in a text editing software program such as Notepad or Wordpad. Extreme caution should be taken when working with the Added Quantities in this manner, as the entries need to be in a specific order and numbered in a specific manner.

Mass Haul Diagram

- Select **Apply in the Cross Section Tab** Identify point to plot in Microstation file or Reject
- *Exaggeration / Horizontal:* should be set to 0.50 and *Exaggeration / Vertical:* should be set to 0.02.

Volume Reports

- Select **Apply in the Cross Section Tab**> Bentley Civil Report Browser>
- Select SDDOT > SD_Volumes.xsl

Volumes.xsl could be used to verify MDC quantities for a check

- File <Save As…> to save this report results to the project directory as u:\rd\prj\COUN\PCN#\endvol.html.

- **Save the Roadway Designer and File save as PCN#.ird.**

Appendix A – Developing an InRoads Project

An InRoads Project (*.rwk) file can be created, that can be opened at the beginning of each InRoads session. This file gives the user the ability to open each desirable component of the modeling process without having to open each component individually.

- Open the Surface files (*.dtm) for the project, beginning with PCN#org.dtm (from the REGION project folder), and then mainline.dtm files.
- Open the Geometry project file (ePCN#.alg).
- Open the Template Libraries file (PCN#.itl).
- Open the Roadway Design file (PCN#.ird).
- Open, if applicable, the Drainage file (PCN#.sdb).
- InRoads **File > Save As**
- <Options…>
  - Select the *Surfaces* tab.
    - ✓ Toggle *Add* for the PCN#org surface. (Road Design does not have access rights to the Region project folders, thus *Update* must not be toggled on for this surface, as Update also saves any modifications to the component file, when the InRoads session is ended or the Project file is saved).
    - ✓ Toggle *Add* and *Update* for the remainder of the surfaces.
  - Select the *Geometry Project* tab.
    - ✓ Toggle *Add* and *Update* for the Geometry Project.
  - Select the *Template Library* tab.
    - ✓ Toggle *Add* and *Update* for the Template Library.
  - Select the *Roadway Design* tab.
    - ✓ Toggle *Add* and *Update* for the Roadway Design.
  - Enter PCN# in the *File Name:* field.
- <OK>

The InRoads Project file can also be created by copying u:\rd\Bentley\V8i\InRoads\data\English\rd.rwk to the appropriate project file. Once the copy has been completed utilize a text editor program to edit the path for each respective component of the file.

Appendix B - InRoads Storm & Sanitary Workflow, V8i

Table of Contents

Starting InRoads Storm & Sanitary

Need to contact the HELP desk to have BIT install the software on your computer.

Loading Inroads Storm & Sanitary after software installed

Inroads toolbar: **Tools > Product Add-Ins >** check **InRoads Storm & Sanitary** box, **OK**
This will add **Drainage** to the Inroads toolbar and also a Drainage > Options under Tools.
Save settings to have this automatically load for this project, but should toggle off when not in use since it checks out a license every time it is loaded.

Open Inroads Storm & Sanitary right away when starting Inroads if working on storm sewer. Opening the .itl and .ird files before opening Inroads Storm & Sanitary will cause these files to become inaccessible and will need to be reloaded again.

Create Drainage (.sdb) file when first beginning

File > New > Drainage Tab >
Name: **PCN#** (will automatically add the extension .sdb)

Save Drainage (.sdb) file when needed

Open Drainage (.sdb) file

File > Open >
set Files of type: to Drainage (*.sdb), then select **PCN#.sdb**
Can also open the PCN#.sdb by adding to the PCN#.rwk file and opening only that.

Be sure to have the project geometry and surface files loaded for InRoads Storm & Sanitary to reference from.

HINT: Be sure you have run **Bentley Config Utility (BCU.exe),** so your computer has the latest SDDOT standard drainage files loaded. Recommend checking that the correct i_structure.dat file is loaded every time InRoads Storm & Sanitary is used by looking under **Tools > Drainage > Options > Inlet Tab**, and that Type B is an option under class: when the type: is set to combination.

Recommend creating **sPCN#.dgn** as a 3D graphics file in your PROJECT folder using microstation. This file will be used to design the storm sewer system.

Storm Sewer Design Procedure

1. Set preferences and symbology for network structures.

Most of the following are typical project settings that should automatically be loaded from the default preference, which is in rd.xin and loaded when BCU.exe (Bentley Config Utility) is run. These settings should be double checked before placing structures and computing to meet project specific needs.

Tools > Drainage > Options

General Tab:

Drainage Structures File:	sddot_ i_structures.dat (the program seeks this file from C:\dot\rd\data\sddot_i_structures.dat which is loaded when BCU.exe is run)
Area Units:	ac
Discharge Units:	cfs
Status:	Fixed for inlets, Resize for pipe (See following hint)

HINT: Under the General Tab, Status: **Fixed** needs to be toggled while placing inlets, but should be set back to **Resize** when placing pipes to have the software resize pipes during the analysis. If any inlet in the network is toggled to resize, InRoads Storm & Sanitary will produce an error message about inlet surcharging when analyzing the network. It may be easiest to leave as Resize and edit the inlets after they are placed. To change this after an inlet is placed, go to **Drainage > Edit/Review, select the inlet, toggle on Fixed at the bottom of the Inlet Tab, Apply**.

Structure IDs Tab:

Toggle on Use Prefixes

Prefix:	Pipe:	P
	Channel:	CH
	Culvert:	CV
	Manhole:	MH
	Inlet:	IN
	Pump:	PM
	Area:	A
	Zone:	Z
	Utility:	U

Gutter Section Tab:

Type:	Composite
Gutter Width:	2.00 ft
Side Slope:	20.00:1 (.05 ft/ft)
Longitudinal Slope:	Compute from DTM
Transverse Slope:	Compute from DTM (usually 50:1 or .02)
Roughness:	0.015 (Set ‘n’ value based on 12.8-B in the Drainage Manual)
Maximum Spread	8.00 ft

Design Tab:

Design Equation: Manning

Structure: Set parameters for each type of structure to be placed as follows:

Pipe:

Minimum Height:	18 in.
Maximum Height:	200 in.
Minimum Velocity:	2 ft/s
Maximum Velocity:	40 ft/s
Depth to Height Ratios:	(Used only when creating a Sanitary flow system)

For Height up to: (in.)	Use Ratio of:
15.00	0.50
150.00	0.75
999.00	0.93

Inlet: The following parameters are applied to all the appropriate inlets during the design analysis of the network, as performed in step 4, and cannot be changed for different inlets during a single analysis. The following values listed are for most typical uses of the standard inlet types, except a Type B-in sump. To check a Type B-in sump, input the values listed farther below, and run a separate design analysis just for the non-typical Type B-in sump inlet results.

Typical Inlet Uses (Type B-on grade, all Type S & all Type C):

Curb Height:	6.0 in	For typical curb & gutter sections like Type F & B. Does not include inlet depression.
Curb Opening Height:	6.1 in	This parameter is only used for curb opening (Type S) and Combination (Type B) inlets in sump This value should be the total opening height with depression below the gutter subtracted out (6.1”-3.4”=2.7”).
Curb Length:	3.00 ft	Only used for Combination Inlets (Type B). Normally this length should be the same as the grate length, so the curb opening capacity is neglected, as is standard design according to HEC22. If the curb length is longer than the grate, then the extra length is assumed upstream of the grate, and flow is taken into only the extra curb opening length and then the grate.
Orifice Depth:	0.52 ft	This parameter is used for all inlets except curb openings (Type S). This value is for a Type C inlet, Neenah R-3457-C2 B, and is the head where flow changes from weir to transitional flow on the Neenah website (www.nfco.com). Determines whether a grate is in weir or orifice flow in a sump location. This is also depth where curb opening orifice capacity is added with the grates for a combination inlet (Type B). This depth is compared to the gutter depth plus depression, however, depression cannot be input for grates in sump locations.

Type B-in Sump: (will need to run a separate analysis with these parameters)

Curb Opening Height:	4.5 in	See discussion above.
Orifice Depth:	0.49 ft	From Neenah R-3067-V V. See discussion above.

2. Lay out network structures

Drainage > Lay Out

HINTS: Place junction structures first such as inlets and manholes, then connect with pipes.

When placing inlets be sure the subgrade (mainline) surface is active, so the gutter section uses the correct transverse (typically 2%) and longitudinal slope, if computing slope from DTM. These slopes are important when computing flows and spread.

When placing Type S inlets, be aware that the offset to the center of the inlet is behind the curb & gutter, so the subgrade surface is much higher than that below the roadway surfacing. This may cause the program to set the initial pipe elevation too high at this inlet when it maintains the 1 ft. minimum subgrade cover over the pipe. You will need to adjust the pipe elevation. Also adjust the inlet elevation accordingly based on the finished gutter or grate elevation.

Inlet Tab:

Options (Button at bottom): Select and set the parameters needed as shown below under **Options…** before placing each inlet.

Inlet ID:	Set the number as needed or use automatic number.
Location:	Set as needed
Angle:	Will come in as set in **Drainage Options, Inlet, Orientation**
Long. Slope:	Will come in as set in **Drainage Options, Gutter Section**
Transverse Slope:	Will come in as set in **Drainage Options, Gutter Section**
Connecting Pipes:	Add connecting pipes if needed, not typically done.

Options (Button at bottom): Takes you to **Drainage Options, Inlet**:
(Can also get to this by Tools > Drainage > Options, Inlet Tab)
Input the type of inlet you want to place with the different options and parameters listed as follow:

Type B Inlet (On-Grade):

Type:	Combination
Class:	Type B
Grate Size (LxW):	3.0 x 1.5 (Choose the one that gives the vault size needed, as will show below, to fit pipe in)
Vault Shape:	Box
Vault Size (LxWxT):	3 x 2 x 6 ftxftxin (Change to size needed to fit pipe)
Placement Offset:	0
Location:	**On-Grade**
Connection Point:	Inside (pipe connects to center of inside wall)
Depression:	0.0 in
Drop Across:	0.0 ft
Maximum Depth:	10 ft (According to standard plate)
Depth below Invert:	0.0 ft
Grate Cover:	45 % (Percent flow is restricted by bars of grate. Only used for orifice flow in sump)
Clogging:	0 % (Assume no clogging of inlets)
Intercept Flow:	60 % (Ignored since inlet size is set to fixed)
Orientation:	Parallel to Alignment (Change as needed)

Type B Inlet (in Sump): These inlets are typically not used in sump conditions, unless the gutter flow is 1.0 cfs or less.

Input the same parameters as above Type B Inlet (On-grade), except as follows:

Location: **Sump**
Stand Height: 0.0 ft
Intercept Flow cannot be input

Type S Inlet (in Sump):

Type:	Curb Opening
Class:	Type S
Opening Length:	5 or 10 (Choose the one that gives the vault size needed, as will show below, to fit pipe in. 10' lengths are generally used in sump.)
Vault Shape:	Box
Vault Size (LxWxT):	11 x 4 x 6 ftxftxin (Change to size needed to fit pipe)
Placement Offset:	0
Location:	**Sump**
Connection Point:	Inside (pipe connects to center of inside wall)
Depression:	3.4 in
Drop Across:	0.0 ft
Maximum Depth:	8' and 10' (Varies depending on vault size. Depths shown are from the top back of curb. From standard plates – 8' for 4'x6' & 4'x11', 10' for 7'x11')
Stand Height:	0.0 ft
Depth below Invert:	0.0 ft
Orientation:	Parallel to Alignment (Change as needed)

Type S Inlet (On-Grade): These inlets are typically not used on-grade but may produce lower spread rates if the roadway profile is flatter. Input the same parameters as above Type S Inlet (in Sump), except as follows:

Location: **On-Grade**
Depression: 3.4 in (This is the depression below the gutter bottom just upstream of the inlet opening)
Stand Height is not input
Intercept Flow: 60 % (Ignored since inlet size is set to fixed)

Type C Inlet (in Sump):

Type:	Median Drop (this type uses 4 weir sides vs. 3 for grates)
Class:	Type C
Grate Size (LxW):	4 x 3 (Choose the one that gives the vault size needed, as will show below, to fit pipe in)
Vault Shape:	Box
Vault Size (LxWxT):	4 x 3 x 6 ftxftxin (Change to size needed to fit pipe)
Placement Offset:	0
Location:	**Sump**
Drop Across:	0.0 ft
Maximum Depth:	10 ft
Stand Height:	0.0 ft
Depth below Invert:	0.0 ft
Grate Cover:	50 % (Percent flow is restricted by bars of grate Only used for orifice flow in sump)
Clogging:	0 % (Assume no clogging of inlets)
Orientation:	Parallel to Alignment (Change as needed)

Type C Inlet (On-Grade): These inlets are typically not used on-grade. Input the same parameters as above Type C Inlet (in Sump), except as follows:

Location:	**On-Grade**
Stand Height:	(No input)
Intercept Flow:	60 % (Ignored since inlet size is set to fixed)

Pipe Tab:

Options (Button at bottom): Select and set the parameters needed as shown below under **Options…** before placing each pipe.

Pipe ID:	Set the number as needed or use automatic number.
Location:	Set as needed
Elevations From:	Soffit. Toggle on to align inside top of pipe, resulting in abrupt drops in flowline. If not toggled, pipe flowlines will be aligned. See SD Drainage Manual for best method to use. Generally, hydraulic characteristics are better when top of pipes are aligned. Aligning pipe at flowlines is typically done in flat terrain. This toggle will be used by the software to initially set the pipe elevations. When individuals adjust the pipe elevations manually, as is typically always needed, they will need to match soffits themselves, if so desired.
Invert In, Invert Out & Slope:	Set these 3 parameters as desired. The software analyzes the pipe at these elevations, and does not automatically adjust during the design analysis. Users will need to review the initial elevations set by the software, and adjust as needed for better flow characteristics and meet cover requirements. One parameter will need to be fixed. To fix one correctly: toggle it off so it can be edited, type in what you want to be set, then toggle it on. Edit one of the other parameters as desired, and it will automatically update the last.

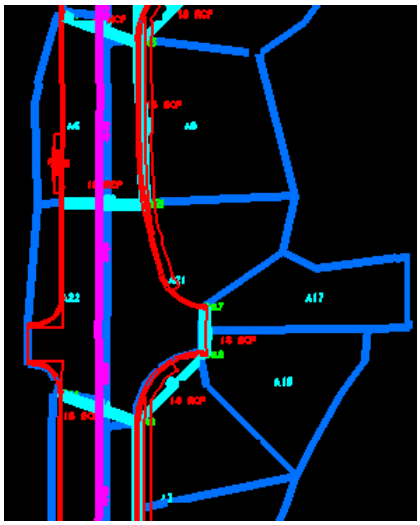
Options (Button at bottom): Takes you to **Drainage Options, Pipe**:
(Can also get to this by Tools > Drainage > Options, Pipe Tab)
Input the type and size of pipe you want to place with the parameters listed as follows:

Shape:	Circular, Box, Elliptical or Pipe-Arch	(select from available)
Material:	RCP, CMP or PVC	(select from available)
Size (_x_xT):	(select desired size from those available, listed in inches)	
Min. Slope:	200:1	
Max. Slope:	5:1	
Min. Cover:	1.0 ft	
Max. Cover:	20 ft	(Check max. cover from SD Drainage Manual)

After drainage structures are placed they can be changed by:
Drainage > Edit/Review , then select structure to be edited
(or can right click on the structure ID and select Edit/Review under the InRoads window)

3. Compute flow and attach drainage areas.

Create shapes of the drainage areas flowing to each inlet in the network using microstation tools such as Place Smartline.



Tools > Drainage > Options

Area Tab:

Rainfall Method:	IDF File (See below)
Frequency:	10 yr
Time of Concentration:	Kirpich: 0.0078 (rounds to 0.01) as the regional constant
Runoff Coefficient:	Can input a value or hit the Compute (button) to determine a value that will be used as the default for all the areas in the network. Typically the Runoff Coefficient will be input or computed separately for each drainage area under *Drainage>Flows>Compute Flow* and not at this location.

IDF File: The appropriate idf file (rainfall intensity duration frequency data), used to compute the flows by the rational method, will need to be set in the project defaults by the following:

File > Project Defaults, with the cursor in **Rainfall Data**, select Browse…, go to C:\dot\rd\data\ to select the correct CITY.idf file based on the location in the state. See the SD Drainage Manual (Fig 7.13-G) for the city to use.

HINT: Whenever flows are to be computed, double check that the correct rainfall data file (City.idf) is selected in the project defaults. The project default should keep the same rainfall city until it gets changed.

NOTE: If the designer wishes to calculate flows for a storm frequency other than what was originally specified (i.e. 100 yr storm vs. 10 yr storm) the following steps need to be followed.

1. Under the Tools > Drainage > Options > Area tab change the frequency to the desired storm.
2. Under each of the established drainage areas (Edit/Review Area), toggle from the Time of Concentration data box to the Intensity data box. Storm intensities will update with this step.

Simply changing the storm frequency under the Tools > Drainage > Options > Area tab will not change the rainfall intensities for the drainage areas. Each and every established Area data set will need to be updated as listed above.

Drainage > Flows > Compute Flow - Computes flow from drainage areas and inputs into the network.

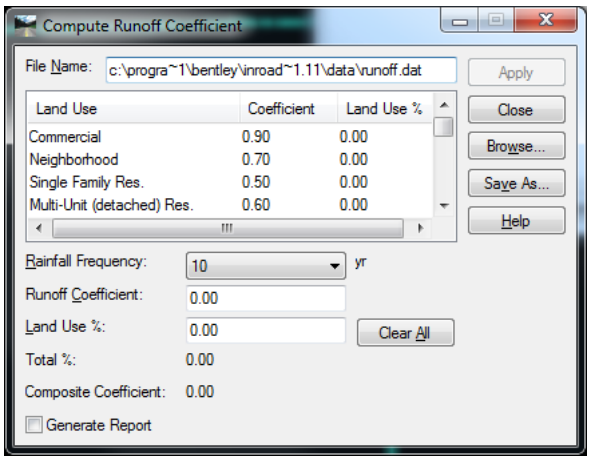
Options (Button) can set the parameters as explained previously for *Tools>Drainage>Options.* Recommend double checking that the correct city.idf file is used.

Rational Tab: (Q=CIA)

Area ID:	Use automatic number or input a number. May want to match the Area ID to the corresponding Inlet ID.
Drainage Area:	Click the Locate button and select graphic shape of the drainage area as created above, or input area in acres.
Runoff Coefficient:	Compute based on land use values and % of use, as shown below under **Compute Runoff Coefficient**, or input a value.
Time of Concentration:	Toggle on and typically input the minimum 5 minutes or, **Compute Time of Concentration** as shown below for larger areas
Intensity:	Don't toggle on. The intensity from the specified City.idf file will be used.
Peak Flow:	Shows computed value based on above parameters.
Attach To:	Click the Locate button and select the inlet or pipe that this drainage area will flow to.

Compute Runoff Coefficient:

File Name:	C:\Program Files\Bentley\InRoads Group V8.11\data\runoff.dat
Rainfall Frequency:	10 yr
Runoff Coefficient:	Shows the coefficient of the highlighted land use. Note: The coefficients change for different frequency.
Land Use %:	Input the percentage of each type of land use in the drainage area, until there is a total of 100% below.
Total %:	Automatically adds up all the Land Use % input. Needs to be 100% before computes composite coefficient.
Composite Coefficient:	Computed runoff coefficient based on land use %.



Compute Time of Concentration: Use to check if the following Result is greater than 5 min.

Method: Overland Flow

Drainage > Flows > Inject Flow (or **Drainage > Edit/Review > Flow Tab, Injected Flow:**)

Injects flow into a network where needed instead of computing flow from an area.

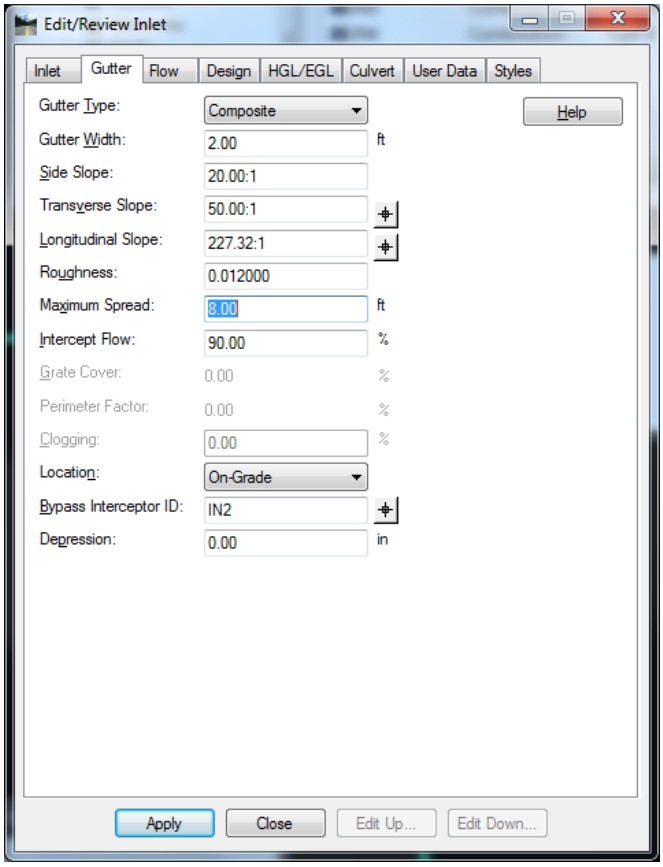
Note: When injecting flow into an inlet, the flow will first go into the gutter and spread will be computed from the injected flow. To inject flow directly into the inlet without first going into the gutter, then create a small pipe into the inlet and inject flow into the pipe.

Bypass flow interceptor needs to be set for each On-Grade inlet in the network by the following:

Drainage > Edit/Review, select structure to be edited,
or can type in the structure ID in the Microstation key-in window.

Gutter Tab:

Bypass Interceptor ID: Select structure that the bypass gutter flow will flow to. Apply



HINT: Recommend double checking all the inlet, gutter and flow parameters before the next step of designing the network.

4. Design the network

Drainage > Network > Design

Toggle on “Tree Network Containing:” under Structures, and select any structure in the network to be analyzed.

Toggle on “Generate Design Log”

Toggle on “Enable Time of Concentration”

“Capture all flow to inlet, ignoring Inlet capacity calculations”:

The network should be analyzed twice, first with this toggled off and then with it on. This follows the method recommended in HEC22.

Toggled Off analysis is needed to accurately compute gutter flow spreads at the inlets. By not toggling this, the inlet gutter bypass flows will be computed and added to the downstream inlet gutters, resulting in more accurate spread computations.

Toggled On analysis is needed to compute pipe sizes. Pipes should be sized assuming all flow enters the inlets and no bypass flows are computed. This may result in slightly larger pipe at the upstream of a network.

Note: Do not toggle “Use Depth to Height Ratios”. These are used for sanitary flows. This could be used for storm sewer if there was a special need to limit the depth of water in the pipes. If so, these ratios are set in the Drainage Options > Design tab.

Note: Peaking Factor Method: is not applicable, since it only pertains to sanitary systems.

Toggle on Generate HGL and EGL.

Toggle on “Use Water Depth” under Outfall Water Level, unless the outfall water level is known.

Toggle on “Greatest Flow” under Trunk Line Path

Ke for Outlet Control Pipes from Drop Manholes: 0.5

Options (Button): To easily change design settings or double check that the settings are correct. The settings should be double checked, especially the rainfall city.idf file.

Apply

If prompted “Bypass flow found from a downstream structure. Do you want to redesign to account for this flow?” Select Yes. This will include bypass flows that were assigned to inlets that may be downstream of the structure but are actually higher in elevation due to the roadway profile. (Storm sewer trunk line goes in opposite direction of roadway grade)

Save Results (Design Log)

Notes: Using InRoads appears to give slightly conservative spread rates. It may be good practice to double check a few spread rates using other HEC22 based software such as Hydraulic Tookbox.

5. Create a profile

Evaluation > Profile > Create Profile

Load the **Storm** Preference

Under Create Profile:

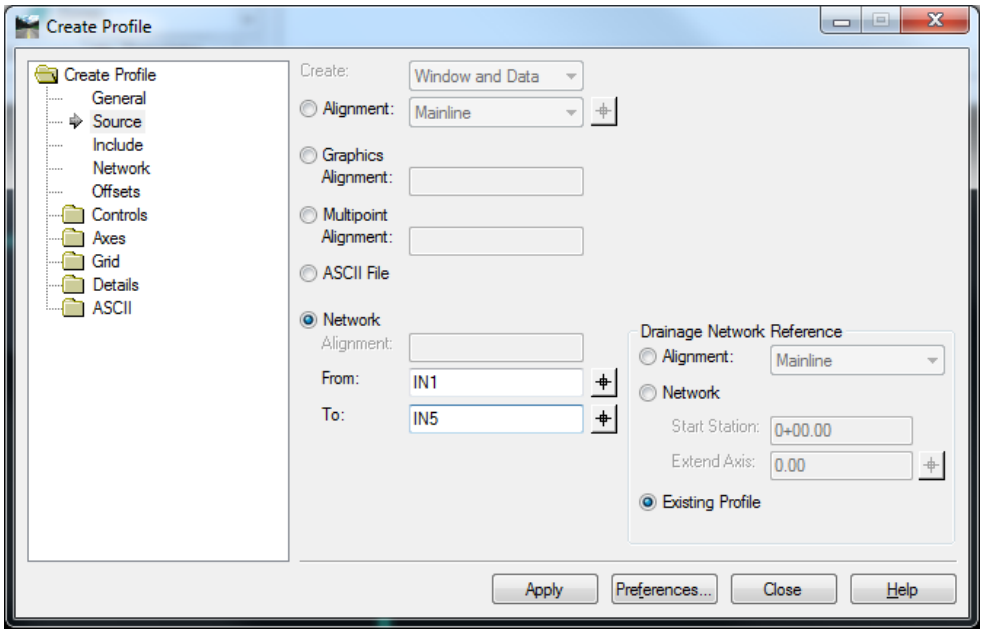
Select Source Leaf:

Toggle on Network

From: & To: Select Structures that you want displayed on the profile.

Toggle on “Existing Profile” under Drainage Network Reference.

Apply (Button). InRoads will prompt you to > Identify Profile. Data click on the profile that you want the storm sewer displayed.

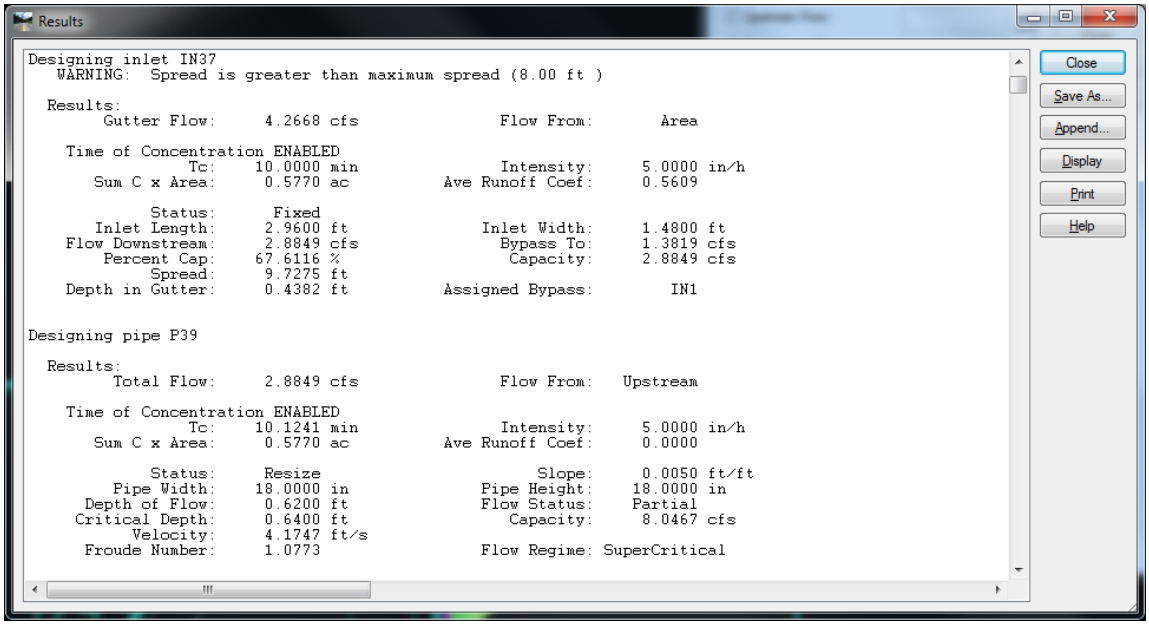


6. Analyze the network

Analyze the network by reviewing the design log and network profile that were created as above.

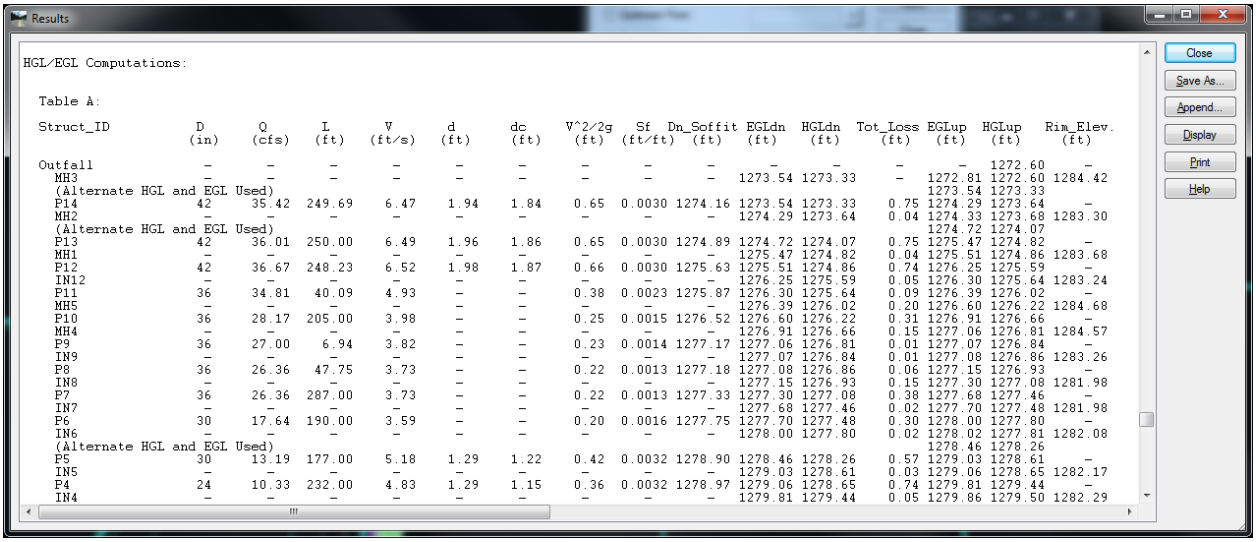
Design Log: The design log was created as above by toggling on Generate Design Log when designing the network under **Drainage > Network > Design**.

Review the design log for warning messages such as: spread greater than maximum spread.




```
Designing inlet IN37
   WARNING:  Spread is greater than maximum spread (8.00 ft )

  Results:
        Gutter Flow:     4.2668 cfs              Flow From:       Area

    Time of Concentration ENABLED
                 Tc:    10.0000 min                Intensity:     5.0000 in/h
      Sum C x Area:     0.5770 ac           Ave Runoff Coef:     0.5609

            Status:      Fixed
       Inlet Length:     2.9600 ft             Inlet Width:     1.4800 ft
    Flow Downstream:     2.8849 cfs              Bypass To:     1.3819 cfs
        Percent Cap:    67.6116 %                 Capacity:     2.8849 cfs
             Spread:     9.7275 ft
    Depth in Gutter:     0.4382 ft           Assigned Bypass:        IN1


Designing pipe P39

  Results:
         Total Flow:     2.8849 cfs              Flow From:   Upstream

    Time of Concentration ENABLED
                 Tc:    10.1241 min                Intensity:     5.0000 in/h
      Sum C x Area:     0.5770 ac           Ave Runoff Coef:     0.0000

            Status:      Resize                      Slope:     0.0050 ft/ft
        Pipe Width:    18.0000 in               Pipe Height:    18.0000 in
     Depth of Flow:     0.6200 ft               Flow Status:    Partial
    Critical Depth:     0.6400 ft                  Capacity:     8.0467 cfs
          Velocity:     4.1747 ft/s
     Froude Number:     1.0773                  Flow Regime: SuperCritical
```

The bottom of the design log shows HGL/EGL Computation Results. Review these and the profile to see that the HGL & EGL meet criteria discussed in the Road Design Manual, Drainage Chapter 11. Some criteria to meet include: keeping the HGL below the finished roadway surface and having correct values for the outfall. HGL is a red dashed line on profile and EGL is a green dashed line.



HGL/EGL Computations:

Table A:

Struct_ID	D (in)	Q (cfs)	L (ft)	V (ft/s)	d (ft)	dc (ft)	V^2/2g (ft)	Sf (ft/ft)	Dn_Soffit (ft)	EGLdn (ft)	HGLdn (ft)	Tot_Loss (ft)	EGLup (ft)	HGLup (ft)	Rim_Elev. (ft)
Outfall	–	–	–	–	–	–	–	–	–	–	–	–	–	1272.60	–
MH3	–	–	–	–	–	–	–	–	–	1273.54	1273.33	–	1272.81	1272.60	1284.42
(Alternate HGL and EGL Used)													1273.54	1273.33	
P14	42	35.42	249.69	6.47	1.94	1.84	0.65	0.0030	1274.16	1273.54	1273.33	0.75	1274.29	1273.64	–
MH2	–	–	–	–	–	–	–	–	–	1274.29	1273.64	0.04	1274.33	1273.68	1283.30
(Alternate HGL and EGL Used)													1274.72	1274.07	
P13	42	36.01	250.00	6.49	1.96	1.86	0.65	0.0030	1274.89	1274.72	1274.07	0.75	1275.47	1274.82	–
MH1	–	–	–	–	–	–	–	–	–	1275.47	1274.82	0.04	1275.51	1274.86	1283.68
P12	42	36.67	248.23	6.52	1.98	1.87	0.66	0.0030	1275.63	1275.51	1274.86	0.74	1276.25	1275.59	–
IN12	–	–	–	–	–	–	–	–	–	1276.25	1275.59	0.05	1276.30	1275.64	1283.24
P11	36	34.81	40.09	4.93	–	–	0.38	0.0023	1275.87	1276.30	1275.64	0.09	1276.39	1276.02	–
MH5	–	–	–	–	–	–	–	–	–	1276.39	1276.02	0.20	1276.60	1276.22	1284.68
P10	36	28.17	205.00	3.98	–	–	0.25	0.0015	1276.52	1276.60	1276.22	0.31	1276.91	1276.66	–
MH4	–	–	–	–	–	–	–	–	–	1276.91	1276.66	0.15	1277.06	1276.81	1284.57
P9	36	27.00	6.94	3.82	–	–	0.23	0.0014	1277.17	1277.06	1276.81	0.01	1277.07	1276.84	–
IN9	–	–	–	–	–	–	–	–	–	1277.07	1276.84	0.01	1277.08	1276.86	1283.26
P8	36	26.36	47.75	3.73	–	–	0.22	0.0013	1277.18	1277.08	1276.86	0.06	1277.15	1276.93	–
IN8	–	–	–	–	–	–	–	–	–	1277.15	1276.93	0.15	1277.30	1277.08	1281.98
P7	36	26.36	287.00	3.73	–	–	0.22	0.0013	1277.33	1277.30	1277.08	0.38	1277.68	1277.46	–
IN7	–	–	–	–	–	–	–	–	–	1277.68	1277.46	0.02	1277.70	1277.48	1281.98
P6	30	17.64	190.00	3.59	–	–	0.20	0.0016	1277.75	1277.70	1277.48	0.30	1278.00	1277.80	–
IN6	–	–	–	–	–	–	–	–	–	1278.00	1277.80	0.02	1278.02	1277.81	1282.08
(Alternate HGL and EGL Used)													1278.46	1278.26	
P5	30	13.19	177.00	5.18	1.29	1.22	0.42	0.0032	1278.90	1278.46	1278.26	0.57	1279.03	1278.61	–
IN5	–	–	–	–	–	–	–	–	–	1279.03	1278.61	0.03	1279.06	1278.65	1282.17
P4	24	10.33	232.00	4.83	1.29	1.15	0.36	0.0032	1278.97	1279.06	1278.65	0.74	1279.81	1279.44	–
IN4	–	–	–	–	–	–	–	–	–	1279.81	1279.44	0.05	1279.86	1279.50	1282.29

7. Redesign the network and recreate a profile if needed.

Make changes to the network to correct problems found in the design log and profile.

8. View Network Layout

Drainage > View > Drainage

9. Annotate the network structures.

Do this for your information only during design. Not to be shown on plan sheets.

Drainage > View > Annotate Structures
This can be customized to show any information needed.

10. Display Network on Final Profiles

For this step, you must receive permission from the drafter to use the dPCN#.dgn. You also need to open the dPCN#.alg in order to annotate the profiles in the d file.

Evaluation > Profile > Create Profile

Load the **Storm** preference.

Under Create Profile:
Select Source Leaf:
Toggle on Network
From: & To: Select Structures that you want displayed on the profile.
Toggle on "Existing Profile" under Drainage Network Reference.
Apply (Button). InRoads will prompt you to > Identify Profile. Data click on the profile that you want the storm sewer displayed.

You will need to select each individual profile that you want to show the storm sewer on so that it displays correctly on the profile sheet.

Note: More often than not, the branch lines will not show up on the profile. The branch lines that do not show up will need to be drawn separately by selecting the network structures From: and To: for the branch line only.

Hint: Once you have the storm sewer on each profile, and you make changes, you can use the **update drainage profile** command. This will update all the profiles at once with the changed data.

Profile > Update Drainage Profile

11. Annotating Drainage Profiles

For this step, you still need to be in the dPCN#.dgn.
In order to annotate the slope of the pipe properly you need to have the proper slope option on.

File> Project Options
Units and Format Tab:
Slope: **50%**

Evaluation > Profile > Annotate Drainage Profile
Load the preference **storm.**

Click <**Apply**> and then select each individual profile.

Hint: Once all the annotation is done, you may need to clean up the profiles, because some of the annotation may be overlapping.

Now that the drainage profile is drawn and annotated you can leave the d file.

12. Storm Sewer on Cross Sections

Evaluation > Cross Section > Cross Sections
Under Update Cross Section: (To add storm sewer to existing cross sections)
Select Storm and Sanitary Leaf:
Select Cross Section Set you would like storm sewer displayed on.
Toggle on “Display On” and select the pipes you want displayed.
Check Redefine Bandwidth and set to 25’ for cross-sections cut every 50’. Select projected pipe and inlets you want displayed.
Hit <Apply>

Note: If the projected pipes and inlets are greyed out, you may need to edit the Storm style to display projected line segments.
Tools > Style Manager
Scroll down to Storm: Click Edit
Select Surface Feature Folder
Under Cross Section Display, Toggle on “Projected Line Segments”
Hit <Apply> and close out of both windows.

13. Generate reports

Tools > Drainage > Reports

Appendix C - Miscellaneous Work Flows

Creating DWG Files from ArcMap for Reference into Microstation

Housekeeping Items:

Before you get started, follow these necessary steps:

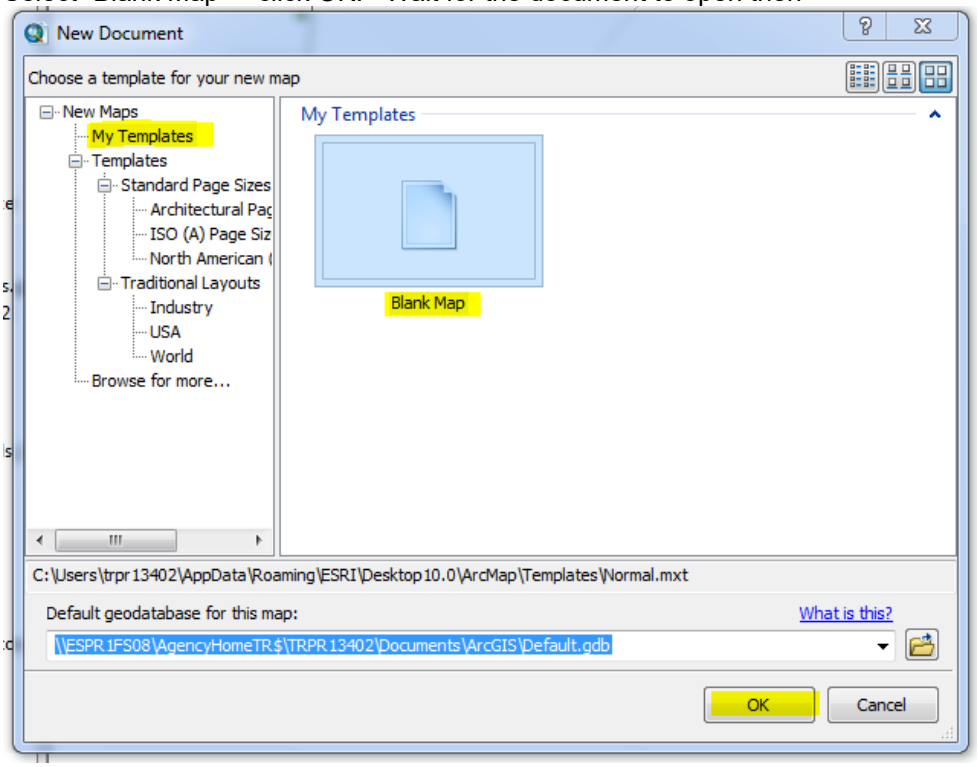
1) Open U:\tim\Temp\Connections and **Copy** all files
2) **Paste** items to C:\Users\trpr1(your #)\AppData\Roaming\ESRI\Desktop10.2\ArcCatalog
3) All Programs – ArcGIS – ArcCatalog 10.2 – Folder Connections – Connect to Folders C, M, & U

Install DataHound

Have you installed DataHound? If so, skip over this step. Otherwise, follow the steps below:

1. Open ArcMap 10.2 – Create a new document – **DO NOT** execute the following steps using an existing mxd file.

2. Select "Blank Map" – click OK. Wait for the document to open then -

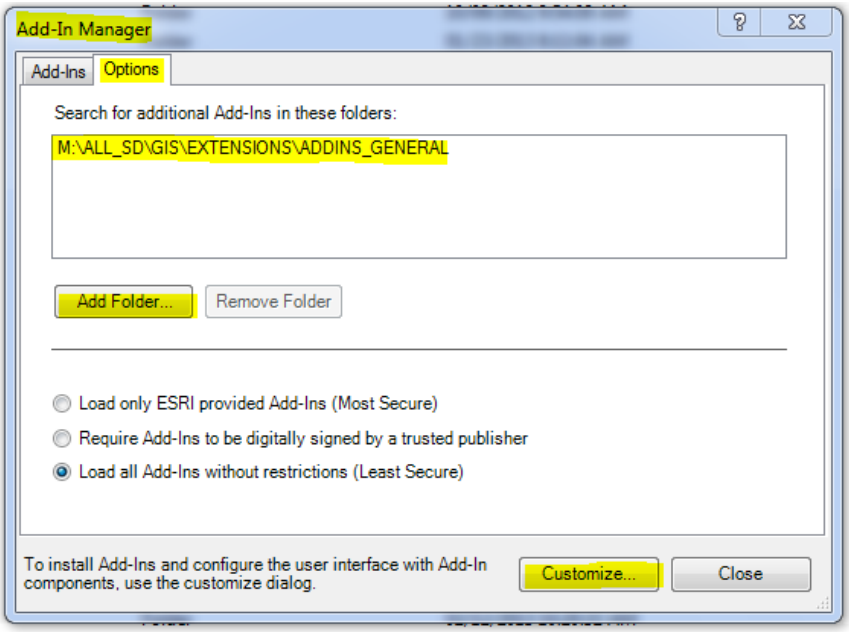


3. Go to the "**Customize**" menu and choose "**Add-in Manager…**"

4. In the Add-in Manager window, select the "**Options**" tab.

5. If your Add-In Manager already has the path highlighted in the previous step, you do not need to add it again. Skip Steps 6 through 10 and begin with Step 11 – "Customize"

6. Press the "**Add Folder…**" button.



7. At the bottom of the "**Browse For Folder**" window, in the text box where it shows your name, highlight the text and delete it.

8. Copy and paste the following path into that same text box:
M:\All_SD\GIS\Extensions\Addins_General

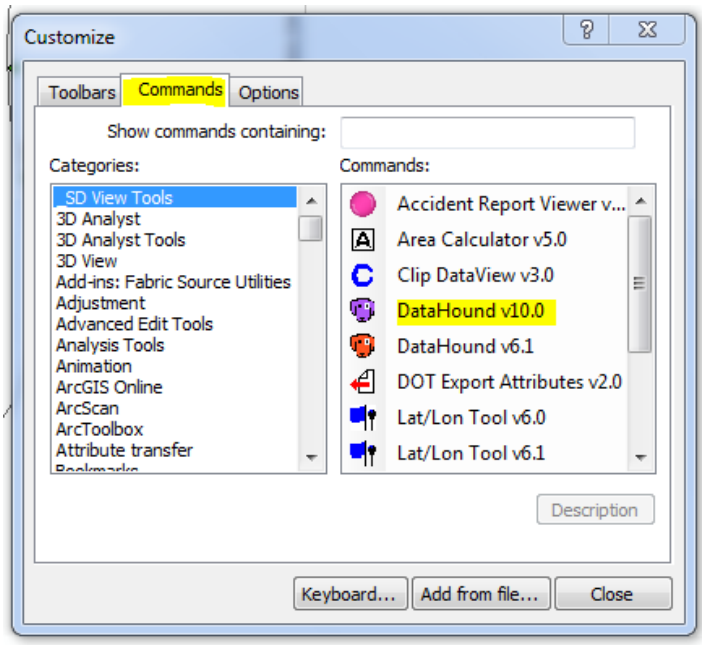
9. Press the "**OK**" button.

10. Wait about 15 seconds until you see the path appear in the window (it should be in all uppercase letters). If you don't see the path appear after 30 seconds, then contact someone in GIS support. Tim Teaford (x6370), Chris Marsh (x6701), Sandra Panicucci (x5688)

11. Open the Customize window:

    - At the bottom of the Add-In Manager window, press the "**Customize…**" button.

12. In the Customize window, select the "**Commands**" tab.



13. Wait for the lists to populate. In the **Categories** list on the left, select "**_SD View Tools**".

14. In the **Commands** list on the right, find your tool(s) and drag them (FYI – you can only drag one tool at-a-time) out onto one of your main toolbars.

15. After you have successfully added the **DataHound v10.0**, REMOVE any other version of the Datahound you have added previously.

16. To remove a tool from your project, select, hold your mouse button down and drag the tool from the ArcMap window into the Customize window and release the tool. It does not matter whether you are in the correct Category, because the Manager knows where the tool belongs.

17. When you are finished, close the Customize window.
18. DO NOT SAVE this new file!
19. Close ArcMap and open your working document – if you have followed the instructions correctly the new Datahound will be in place and the old data hound v6.X will be gone.

Background Processing

This allows you to see the progress on executing export commands:

Open ArcMap – GeoProcessing – Geoprocessing Options – Background Processing: Uncheck Enable

Creating DWG Files from ArcMap

Open ArcMap 10.2 > Choose Blank Map (under My Templates)

Add Information Layers to Map

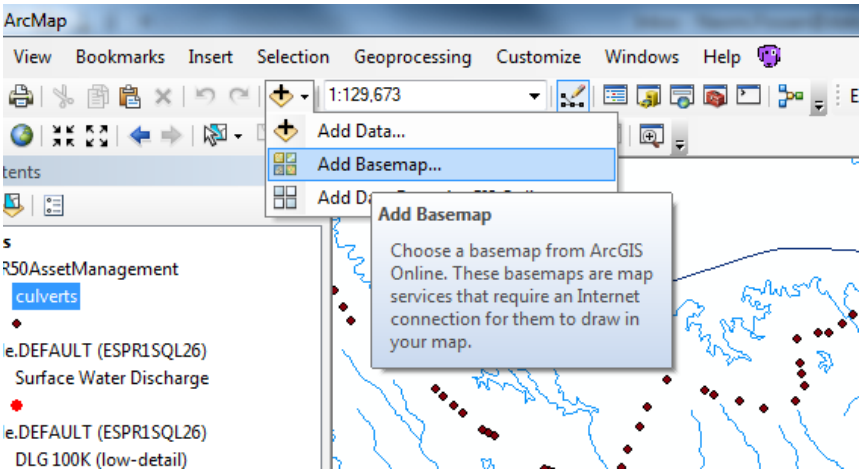
Open DataHound v10.0 > Transportation/Networks > All Roads-DOT (Feature Classes) > Add Layers

Here are a few helpful layers (add as many as desired):

- USGS Quad Map: DataHound > Imagery > DRG's and Other Imagery> DRG's 024K-Statewide > Add Layers
- Floodzones & Wetlands: DataHound > Water Resources > Floodzones-FEMA and Wetland Boundaries-NWI > Add Layers
- MRMs: DataHound > Transportation/Networks > Mileage Reference Markers > Add Layers

Add Aerial Photo to Map

1. Add Basemap (as shown below) > Imagery > Add



Add/Create Data from ArcCatalog

Culvert Inventory Data

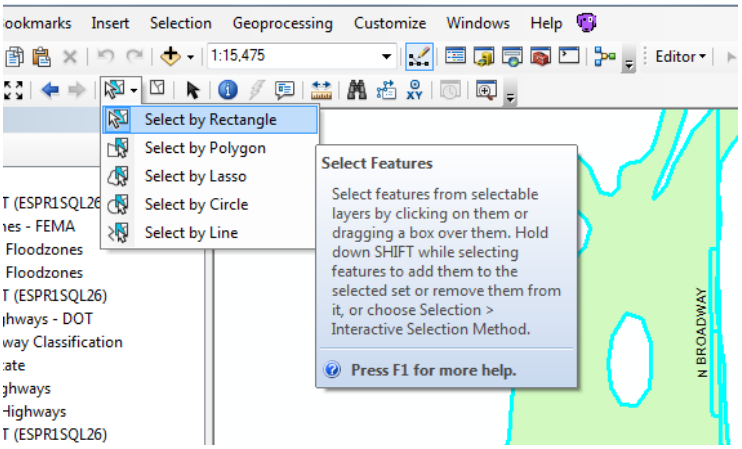
1. Open ArcCatalog > Database Connections > Connect to Asset Management DB as user.sde > Click & Drag to Layers: HR50AssetManagement.dbo.vwCulvertInventory.
2. New Query Layer > check ID > Finish
3. Under Layers, Right Click Culvert Inventory > Display XY Data > Edit > Geographic Coordinate System > North America > NAD 1983 > OK > OK
4. A new layer will be created with point symbols (this takes a few minutes, because it is an inventory of the whole state).
5. Rename layer to "Culverts" or whatever you prefer.
6. Delete/remove the table (this information is incorporated into the new point layer).
7. For more information on the culverts: Right click > Open Attribute Table. (Values of -1 or 1 are True or Yes; Values of 0 are False or No).

Accident Data

1. ArcCatalog > Database Connections > Connect to HR60 as ArcMap.odc > Drag to Layers under Table of Contents: dbo.Accident
2. Repeat Steps 3 thru 6 above.

Create DWG from Layers

1. Select area around your project: Select Features > Select by Rectangle. Draw a rectangle. You'll notice layers are now highlighted.



2. If the project is in State Plane North, skip step 3.
3. Right click on Layers in Table of Contents > select Properties > Coordinate System tab > Projected Coordinate System > State Plane – NAD 1983 (US Feet) > NAD 1983 State Plane South Dakota S FIPS 4002 (US Feet) OK.
4. Open ArcToolbox > Conversion Tools > To CAD > Export to CAD
   Input Features: Choose Layers (You can choose more than one layer. The DWG will create these on individual levels)
   Output Type: DWG_R2010
   Output File: Navigate to your project file and save to "Other Agencies" folder.
   Environments > Output Coordinates >
   For State Plane North: choose Output Coordinate System: "Same as Layer "Local Roads (NSTRI) - DOT"", OK > OK
   For State Plane South: choose Output Coordinate System: "Same as Display"

Arch sites and hydraulic pipe drainage areas can also be exported as DWG and referenced into Microstation.

Reference DWG into Microstation

Attach reference DWG with Attachment Method: Coincident World

Hint: If the attachment does not line up with your project, run Bentley Config.

Arch-Environmental Request

Open the dPCN#.dgn and the rPCN#.dgn Make sure you File/ Compress/ design for each .dgn before converting to dwgs and then copy/place dwgs on the FTP server in the CoPCN# directory.

They are interested in the centerline alignment, stationing and work limits from the dfile and the new ROW, old ROW, and temporary easements from the rfile.

State in the email to the Environmental office what stage you are at with design for your project. You may not have easements or still working on alignment, etc. just let them know. Give the link to the FTP server from the internet with the User Name and Password.

Bluetop Report Workflow

Create or verify there is a project folder: U:\rd\prj\COUNPCN#\Staking\. Save all of the Staking information in this folder.

Create Cross Sections: EVALUATION>CROSS SECTION>CROSS SECTIONS
Make sure the correct Geometry is selected (Mainline)

- Create Cross Sections: Set the Preferences to the desired setting
  - General: Create: Window and Data
    Interval: Set Interval (Normally to 50)
    Surfaces: Select the Design Surface (Mainline) and PCNorg surfaces only
  - Include : Toggle ON “Crossing Features”
    Toggle OFF “Components”
- Controls:
  - Limits: Toggle ON “Station”
    Set Start and Stop Stations

Apply

Create Report: EVALUATION>CROSS SECTION>CROSS SECTION REPORTS
- Main Tab:
  - Cross Section Set: Select target button and data on the cross section set you want to create your report from.
  - Surfaces: select *Mainline*
  - Toggle ON “Include Selected Features Only:”
    - Select: *Centerline, L_Lane, L_Shoulder, L_Subgrade, R_Lane, R_Shoulder, R_Subgrade*
- Slope Staking Tab:
  - Toggle ON > From Surface: > Select *Mainline* > Feature: Select *Centerline*
  - **Apply**

  - Option 1 Deliverable – Evaluation Folder > CrossSectionGradebook.xsl
  - Option 2 Deliverable – Evaluation Folder > CrossSectionSurveyFormat.xsl

Save Report:
- Option 1 - File>SaveAs>U:\rd\prj\COUNPCN#\Staking**DTMNAME_Bluetop.doc**
- Option 2 - File>SaveAs>U:\rd\prj\COUNPCN#\Staking**DTMNAME_Bluetop.txt**

Staking Reports Workflow

The following work for construction staking shall be done in **stakePCEM.dgn**

Drawing Hub Lines

There are 3 lines which must be drawn onto the plan view of the project to create the slope staking report. These are the left hub line, right hub line, and the centerline of the alignment. The left and right hub lines can be drawn manually by using the **smart line** command in microstation. The hub lines are the outermost limits of work (temporary easements or ROW for the project.) Normally the temporary easements are located on level 13 of the "d" file, so turn off all other levels of this reference file. The same goes for level 27 of the "r" file. This will leave only the ROW line in the plan view. Draw each of the hub lines by following the ROW and temporary easement lines from the beginning of the project to the end with one continuous linestring per side. For sections of ROW in curves, snap to the ROW line at every station in order to get your hub line correct where reported at.

Note: The perimeter of the original ground surface should be drawn to check that the hub lines do not go outside of the original ground surface. The hub lines should be moved in over the original ground surface in the immediate area where they fall outside. If hub lines are not brought in, they will break the line segments where outside the original ground when draping.

Tip: The easiest way to draw the left and right hub line is to create one long line string for each hub line with the smart line command from the beginning of the project to the end. Then use the **insert vertex** command located in the Modify toolbar to insert as many points as you need along each hub line.

View Features

The centerline of the project must be drawn in plan view. One method of viewing the centerline is to view the centerline features.

From the InRoads menu bar, SURFACE>VIEW SURFACE>FEATURES.
Surface: select *Mainline*. This should display the list of features for the mainline surface.
Features: select C*enterline*
Apply - Places the centerline on the plan view.
Close the dialog box.

Level 1 in the stakePCEM.dgn file will have to be turned back on to see the centerline feature.

Drape Surface

These 3 line strings must now be draped to the existing surface. (PCEMorg.dtm)

From the InRoads menu bar, SURFACE>DESIGN SURFACE>DRAPE SURFACE. Be sure to have your "Locate Graphics" toggle ON, or you will not be able to select the graphics. You need to make sure the "Locks" toolbar is shown on the top of your Inroads window. (TOOLS>CUSTOMIZE>LOCKS>CLOSE)
Destination Surface: select *PCEMorg*
Graphics>Input Mode*:* select *Single*
Toggle ON "Destination Level:" select *Level 9*
Toggle ON "Delete Original Graphics"
Apply - select the 3 line strings created above (Centerline, Left Hub, & Right Hub) Look at the status bar at the bottom of your screen to make sure you have successfully completed each line.

Verify that you have deleted the original linestring.
Check to see if you have draped the centerline and hub lines to the existing surface by turning off all of the levels except Level 9 and compare the elevations of the draped line to the existing surface.

Import Surface

You will now import the centerline graphics.

From the InRoads menu bar, FILE>IMPORT>SURFACE
From Graphics tab
Surface: select *Mainline*
Load From: select *Single Element*
Elevations: select *Use Element Elevations*
Seed Name: type in *CL_Exist*
Feature Style: select *Centerline*
Point Type: select *Breakline*
Toggle ON *Exclude from Triangulation*
Apply - data click on the centerline graphics. InRoads prompt should read "Import Complete"

Repeat this process for the left and right hubs with the following exception;

Seed Name: Type in *Left_Hub,* or *Right_Hub* (respectively) for both the left and right hub.
Triangulate the Mainline Subgrade surface
From the InRoads menu bar, SURFACE>TRIANGULATE SURFACE
Surface: Mainline
Apply
FILE>SAVE>SURFACE – Saving the surface will save the centerline and hub line feature that you just made.

Create or Update Cross Sections

At this point, all of the necessary features have been imported into the design surface. Now create cross sections in stakePCEM.dgn from the beginning to the end of the project in 100 foot intervals showing the mainline surface and the original ground. (A guideline to create cross sections can be found in the CADD Procedures Manual.) After the cross sections have been cut you need to check to make sure that the CL_Exist, Left_Hub, and Right_Hub features are at the original ground elevation.

From the InRoads menu bar, EVALUATION>CROSS SECTION>CROSS SECTIONS
UPDATE CROSS SECTION>CROSSING FEATURES
Cross Section Set: select the correct cross section set from the drop down menu or data on the "Target" button and data click on the correct cross section set
Toggle ON "Display On"
Surface: select *Mainline*
Feature: select *CL_Exist, Left_Hub*, and *Right_Hub* (you will need to hold in "Ctrl" on your keyboard to select all of the feature names at once)
Apply - review the cross section set to make sure a small white circle has been created at the existing ground elevation for the CL_Exist, Left_Hub, and Right_Hub feature. (Make sure level 44 is ON to see feature circles.)

All of the features (white circles) that are shown on the cross sections will be available to be placed in a report. Additional features should be added the same way that the hub lines features were. All of the features on the mainline subgrade component (not the undercut component) should be shown with the exception of the *exterior boundary* and the features between the centerline and the edge of the roadway such as *left lane, left shoulder, right lane* and *right shoulder,* etc. (be sure to include *centerline*). (Do not show the clearzone point unless there is a break to 3:1).
If a staking contractor asks you for a finished surface staking report then you can display the finished component features on the cross sections and make an additional report.

Create Report: EVALUATION>CROSS SECTION>CROSS SECTION REPORT

Main tab
Cross Section Set: select "Target" button and data click on the cross section set you want to create your report from.

Include: Surfaces: Name: select *Mainline*
Toggle ON "Include Selected Features Only:"
Select: All Features that you want to be added into report
Apply

Save Report:

Report 1: Evaluation>CrossSectionAllFeatures.xsl
File>SaveAs>U:\rd\prj\COUNPCN#\Staking**DTMNAME_Features.doc**

Report 2: Evaluation>CrossSectionSlopeStakeListing.xsl
File>SaveAs>U:\rd\prj\COUNPCN#\Staking**DTMNAME_Slopestake.doc**

If Northing and Easting is requested -
Report 3: Evaluation>CrossSectionGradebookNE.xsl
File>SaveAs>U:\rd\prj\COUNPCN#\Staking**DTMNAME_FeaturesNE.doc**

Staking XML & Machine Grading

The following is data that the Contractor may request from the designer for input into their grading equipment. The grading equipment is able to construct the grades directly from this data. The following is some of the typical information that has been requested. Only some of the following or possibly other data may be requested by individual Contractors based on their equipment needs.

This data may also be requested for construction staking reports that are provided to the staking Subcontractor or SDDOT surveyors. When providing staking reports communicate with the Area Office to see which format the Subcontractor or SDDOT prefers. Other construction staking reports may need to be provided to the surveyor in the form they request in addition to the XML reports.

Create or verify there is a project folder: U:\rd\prj\COUNPCN#\Staking\. Save all of the Staking XML and Machine Grading information in this folder.
Load any microstation file of that project and InRoads software

Load project alignments and surfaces.

1. **XML Alignment Data:** Include all construction alignments. This is usually requested data.
   InRoads:
   File > Translators > LandXML Translator… > Export Alignment Tab:
   Geometry Project: ePCN# (or applicable)
   Include: Put cursor in box then select the "Filter" button.
   Geometry Selection Filter toolbox: Select alignment under Available: and hit Add-> button to move under Selected:. OK.
   Selected: Ensure only one alignment is listed in the box.
   Include Active Children Only: It is suggested to make an individual XML file for every alignment that you have horizontal and vertical data. Toggle on this option and set the alignment active (horizontal and vertical) that you want to make a report from.
   Include All Cogo Points: Don't toggle on (unless you have them for a special situation)
   Linear Units: Select - **US Feet**
   State: proposed
   Save As… button or type in File Name: put file in project folder created above with the name "PCN#_MainlineALG.xml, PCN#_XR106ALG.xml, etc".

Note: When supplying to the Contractor, state that the data is in “US Survey Feet”.

2. **XML Surface Data:** Do for each alignment. This has not always been requested.
   InRoads:
   File > Translators > LandXML Translator… > Export Surface Tab:
   Surfaces: select mainline (or applicable alignment design surface)
   Include Triangles: Toggle on
   Include Features: Don’t toggle on (unless Contractor requests features)
   Linear Units: Select - **US Feet**
   State: proposed
   Save As… button or type in File Name: put file in project folder created above with the name “PCN#_MainlineDTM.xml, PCN#_XR106DTM.xml, etc” or others as below.

   Note: When supplying to the Contractor, state that the data is in “US Survey Feet”.

3. **XML Cross Section Data:** Do for all cross section sets for each alignment for the project.
   InRoads:
   File > Translators > LandXML Translator… > Export Cross Sections Tab:
   Note: If tab is not displayed, see instructions below to add.
   Cross Section Set: select mainline (or applicable alignment set)
   Linear Units: Select - **US Feet**
   State: proposed
   Save As… button or type in File Name: put file in project folder created above with the name “PCN#_MainlineCrossSection.xml, PCN#_XR106CrossSection.xml, etc” or others as below.

   Add Export Cross Sections tab:
   Tools > Application Addins…
   Select **Variable Manager**

   Tools > Variable Manager…
   Select LandXML Translator – Enable Cross Section under Command Behavior:

   Note: This will translate everything in the InRoads Cross Section Set and only things in the InRoads Cross Section Set.

4. **AutoCAD File with Triangles (TIN):** Do for each alignment. This is usually requested data.
   Create new microstation file(s) with the naming below. Contractors may prefer to have all alignments in one file or a separate file for each alignment. Separate files should not require additional discussions or changing levels.
   Draw triangles of mainline (also for other alignment design surfaces if applicable):
   InRoads > Surface > View Surface > Triangles > Surface: mainline
   Draw mainline features (also for other alignments): Only do this if Contractor requests.
   InRoads > Surface > View Surface > Features:
   Surface: mainline (or applicable surface)
   Features: select all
   Apply
   Export to AutoCAD file (.dwg).
   Microstation > File > Save As
   Save as type: Select: Autodesk(R) DWG Files (*.dwg)
   Directories: Put in directory created above.
   Files: Type in name per file naming below. (PCN#_MainlineTriangles.dwg)
   Save > OK

File Naming:

1. PCN#_MainlineALG.xml
2. PCN#_MainlineDTM.xml
2. PCN#_XR106DTM.xml (etc.)
3. PCN#_MainlineCrossSection.xml
3. PCN#_XR106CrossSection.xml
4. PCN#_MainlineTriangles.dgn (& .dwg)
4. PCN#_XR106Triangles.dgn (& .dwg) (etc.)

Contractor Data Requests:

Loren Fuhrmann, Diesel Machinery, requested 1 & 4 with features and all alignments in one TIN file with the mainline data on a separate level from the other alignments.
Derek Bunkers, Bowes Construction, requested 1, 2, & 4 with no features.

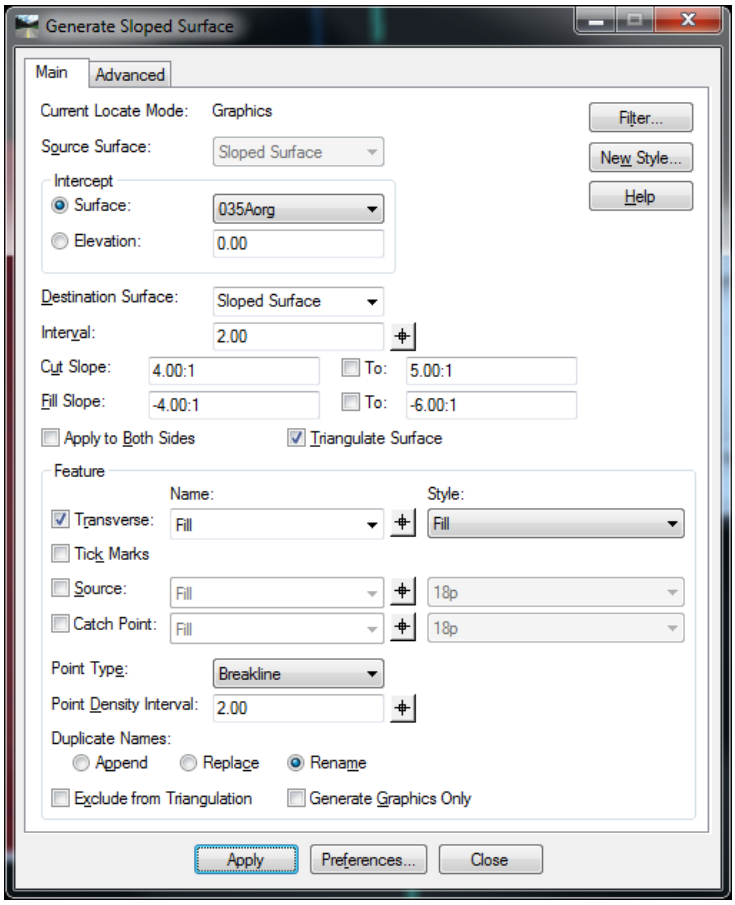
Designers: Please document additional contractor data requests above and let Warren know if other types of information is requested, so we can document.

Generating A Sloped Surface

If you need to generate a surface that has a slope to it and or is not planer. One way to do it is to use the "Generate Sloped Surface Command".

The following steps should be followed.

1. Draw your surface using Microstation. Make sure all elements comprising the surface have the proper elevation. **(az=___)**
2. If the surface is made up of several elements, use the "Create Complex Shape" command from Microstation to link all the individual elements into one.
3. Create a new surface for your sloped surface. **File> Surface >New**
4. Choose **Surface > Design Surface > Generate Sloped Surface**.



5. Fill in the dialog box as shown above. Adjust the slopes, surface name and feature names as needed.
6. Choose apply and follow the prompts on the screen.
7. Triangulate the surface. **Surface >Triangulate Surface**. (If you toggle on "Triangulate Surface" you won't need to do this step.
8. View triangles and contours to verify the surface is what you want.

Note: If your surface is not a perfect plane you will need to draw breaklines at the proper location and elevation using Microstation. Then use the **File>Import> Surface From Graphics** command to import breaklines onto your surface and triangulate again.

General Workflow for CM&P

The Construction Management and Payment (CM&P) system can be used to track your projects progress and construction changes. The program will show on your desktop as a bulldozer icon.

Contact your supervisor to have the program added to your computer.

To Find Your Project

Choose the **Select** icon for "Select A Contract" dialog window.
Contract Status: default is **Open** but can be changed to All if project is not found under Open.
Search For: normally toggle **PCN** then type in number and click **Search.**
Click **OK** or double click project.
The window title bar will show Contract number and PCN (Project Control Number).

To Check Information on the Project

Choose the **Contract** icon for "Manage Contract" window.
This will give general information about the contract including the field Project Engineer under the **Identifying** tab.

To Check Construction Status of the Project

Choose the **WPR** (Work Progress Report) icon for "Bi-weekly Progress" window.
It defaults to the latest report with notes under the **Comments** tab.
Under the **Contract Day Worked** tab it shows the subcontractors and who was working.

To Check Project Construction Changes

By CCO Number

Choose the **CCO** icon for "Contract Change Order" window. Highlight a numbered Change Order to review.

For a summary of why changes were made, create a report:

Reports > **CCO-220B**

Exit when done.

Culvert Design Procedure

Culverts and other highway drainage features should be designed using the SD Drainage Manual as located at Forms & Manuals - South Dakota Department of Transportation. Chapter, section and figure references provided below are from the SD Drainage Manual. The drainage manual has a general culvert design procedure located in Section 10.5.1.

This document provides a simplified culvert design procedure that generally follows the requirements for using the culvert computer software HY-8 (Section 18.2.3 & Fig. 18.2-E). This document was created for use by the SDDOT Office of Road Design and does not replace the need to use the drainage manual. The manual, software and procedure follow the FHWA Manual HDS 5, Hydraulic Design of Highway Culverts. Two Examples are provided at the following locations: U:\rd\Misc\Office\Training\Culvert Design Training\culvert design example 1.docx & U:\rd\Misc\Office\Training\Culvert Design Training\culvert design example 2.docx

HY8 Start Up:

- HY8 software should be installed and run from the C: drive.
- HY8 tutorial is located at C:\Program Files\HY-8 7.30\HY-8 7.3 QuickTutorial.pdf. (Use newer version if available.)
- Starting options: open an existing file or create a new project by add a culvert crossing.
- HY8 project file typical name and location: U:\rd\prj\PCN#\drainage\PCN#.hy8.
- The HY8 file should typically contain all the pipes on the project.
- Under HY8 Project Explorer: Rename each crossing to the station. Additional wording can be added to the crossing name after the station if need to describe the analysis. The culvert name under the crossing can also be renamed.
- Double click on the crossing or the culvert to access and edit the crossing data.
- Exhibit 1 is the HY-8 main window and crossing data window. This shows the required input data including discharges, tailwater, roadway, culvert and culvert site data.
- File>Save As... to save data. File>Save does not appear to save the data in the correct location if at all.

Assemble Site Data: (Chapter 5). Typical site data required is as follows.

- Drainage letter from Bridge Hydraulics Office
- Drainage basin layout in ArcMap from Bridge Hydraulics Office
- Survey data
- Proposed roadway design

HY8 Input Data: Discharge, Tailwater, Roadway, Culvert & Culvert Site

Discharge Data: (Chapter 7)

Discharge Method typically used is minimum, design and maximum. The other methods can be used as needed.

- Minimum flow is typically 0 cfs, but could be set to Q2, Q10 or other if need to review a lower frequency.
- Design flow is the flow at the design frequency. Design Frequency is determined from Figure 7.6-A.
- Maximum flow is typically Q100 or the review frequency (Section 7.6.2.3).

Discharges are determined using the order of preferred methods as specified in Section 7.7.5. This order of discharge methods for Road Design is generally as follows for rural undeveloped drainage basins.

1. USGS 1998 Regression Equations (Section 7.9). Use for drainage areas within the applicable range from Figure 7.9-D. This figure shows that some of the hydrologic subregion equations are applicable for drainage areas under 200 acres. Also consider using this method for all drainage areas over 200 acres even when area is not within range from the figure.

2. Rational Method (Section 7.13). Use for drainage areas under 200 acres where above equations are not applicable.

3. USGS 1980 Hydrograph with 1998 Discharges (Section 7.15). Very rarely used. Use when need to route flows by incorporating upstream storage volume (Sections 10.3.2.8 and 10.7).

For drainage areas under 200 acres where regression equations are applicable it may be worth computing both methods to verify the regression equation results are reasonable.

Discharge computations are theoretical and not exact. This should be taken into account when designing culverts. The new culvert design should be compared with existing culvert size and conditions and what resulting changes to backwater and downstream flows will be.

USGS 1998 Regression Equation discharges can be computed using U:\apps\PROGRAMS\EXCEL\USGS1998.xls. The applicable hydrologic subregion and input parameters are typically obtained from the drainage letter.

Rational Method discharges can be computed using U:\apps\PROGRAMS\EXCEL\Rational Method Discharges.xlsx or the hydraulic toolbox software found at U:\apps\NCHRP\Hydraulic Toolbox\4.1\HydraulicToolbox.exe (Use newer version if available under this same directory). Rational method is Q=CiA. The drainage area is typically obtained from the drainage letter and the remaining input variables are determined by the culvert designer. Guidance for determining the input variables is found in Section 7.13 and also the above spreadsheet. See Exhibit 3A for additional runoff coefficients to those provided in Figure 7.13-A.

- Drainage basin Time of Concentration (Tc) is computed to obtain the appropriate rainfall intensity (i) and can require considerable amount of judgment. The Tc is based on the time it takes water to flow from the most hydraulically remote point of the drainage basin to the culvert (longest time route). The types of flow drainage typically flows in begins as sheet flow, then shallow concentrated flow and finally channel flow to the culvert. The time for each type of flow should be computed.
- Length and slope of each of these types of flow should be determined from the survey where available, but most often must be estimated from the quad map. A good source for the quad map with drainage basin layouts is the ArcMap file provided by the Bridge Hydraulics Office. Measurements can be made directly in ArcMap. See Exhibit 2 for ArcMap view and notes on use. ArcMap files and quad maps can be referenced into microstation if desired by following other workflows concerning Wetlands from GIS and 7.5 Minute Quadrangles referenced into Microstation Files.
- Aerial photo from the ArcMap file, google map, or others can be used to estimate the flow type limits and runoff coefficients.
- Channel flow time in the drainage basin requires the channel velocity be computed. The velocity is computed by the manning's equation for the surveyed or estimated channel section assuming bank-full condition. The channel velocity can be computed using the channel analysis tool in the hydraulic toolbox software referenced above. The hydraulic toolbox file and each analysis should be located and named similar to the HY8 file discussed above except with file ending in .hyd. Hydraulic Toolbox reference guide is located at U:\apps\NCHRP\Hydraulic Toolbox\4.1\Desktop Reference Guide.pdf (Use newer version if available under this same directory).

Tailwater Data: (Section 10.3.2.4)

- Model the actual tailwater water surface at the culvert outlet by the appropriate channel type available in HY8.
- Typically an irregular channel section is input using survey data and a typical cross section of the downstream channel near the culvert outlet. If a more typical channel section is taken farther

downstream, then the elevation of the section should be adjusted up as if the section was taken at the culvert outlet location based on the channel slope. The channel invert flowline elevation is typically similar to the culvert outlet elevation or the top of embedment depth where applicable, as discussed below.
- The slope of the tailwater channel should be obtained from the survey, but can be estimated from the quad map if survey is not available or sufficient. Quad map measurements can be taken from the ArcMap file.
- Manning's n values can be estimated from Exhibit 3B or Section 9.3.3.
- Tailwater elevations must correspond with the elevations for the roadway data and culvert site data.

Roadway Data: (Section 10.4.7)
- Model the actual overtopping section where culvert backwater will first begin to either flow over the roadway or to a different drainage basin. This overtopping section is the lower of the possibilities listed in Section 10.4.7, which may or may not be the same as the culvert allowable design headwater. The overtopping section should be modeled to elevations on both ends that are above the resulting maximum discharge headwater elevation, so an accurate maximum headwater is computed.
- Roadway Surface will be input as paved or gravel as appropriate. Use gravel for grassed locations assuming the grass will typically lay down as a more smooth surface.
- Top width will be the width of the item that is overtopping such as the top of finished surfacing on the highway or approach, 10' for ditch blocks and 50'+/- for overtopping the summit of a ditch grade.
- Roadway elevations must correspond with the elevations for the tailwater and culvert site data.

Culvert Data: (Section 10.3.3)
- Shape and Material (Section 10.3.3.1)
- Diameter/Size (Section 10.3.3.3). Applicable culverts should meet minimum culvert width requirement in the Nationwide Permit as referenced in the following embedment depth discussions.
- Embedment Depth (Sections 10.3.4.6 & Appendix 10.A). This is the depth the culvert is countersunk below the channel flowline elevation for passage of aquatic organisms. The Bridge Hydraulics Office will provide these locations in the drainage letter. Embedment depth requirements are set by the US Army Corps of Engineers in the link "Nationwide Permit Regional Conditions for South Dakota" under http://www.nwo.usace.army.mil/Missions/RegulatoryProgram/SouthDakota.aspx. This depth is based on the culvert type, size and drainage area. Only one of the culverts of a multiple culvert installation may need to be countersunk depending whether the minimum culvert width requirement in the Nationwide Permit is met.
- Manning's n (Figures 10.10-A). If embedment depth is specified then n values will be required for the pipe sides and for the natural bottom in the pipe.
- Culvert Type is typically set to straight. Broken-back type should be used when there is a change in slope along the length of the culvert, as done for downspouts (Sections 10.3.3.8, 10.3.3.9 & 10.9). The other inlet configurations are very rarely used (Section 10.8).
- Inlet Depression is very rarely used.
- Inlet Configuration should be set as follows (Section 10.3.3.11, Fig. 10.10-B & 10.10-C).

Sloped Ends – Mitered to Conform to Slope or Mitered – RCP, RCP Arch*, CMP & CMP Arch
Safety Ends – Mitered to Conform to Slope or Mitered – RCP, RCP Arch*, CMP & CMP Arch
Flared Ends – Square Edge with Headwall or Headwall - RCP, RCP Arch, CMP & CMP Arch
Sectional Ends – Square Edge with Headwall - RCP & RCP Arch
No Ends on CMP – Thin Edge Projecting or Projecting - CMP & CMP Arch

* HY8 does not provide a mitered edge treatment for RCP Arch, therefore change material to corrugated steel or aluminum and change the n value to 0.012. This follows footnote 2 in Figure 10.10-C. Most likely the steel size will need to be defined from historic sizes with the one that matches the similar area of the desired RCP Arch.

Culvert Site Data: (Sections 10.3, 10.3.1.2, 10.3.3.4 thru 10.3.3.7)

- Culvert Invert Data is typically the option to use to set the culvert elevation and length.
- Inlet and outlet elevations are typically set to the actual culvert flowline elevations where the top of the pipe daylights and not at the end of the end sections. These elevations need to correspond with the tailwater and roadway elevations input above. If the culvert is countersunk by the embedment depth then the culvert inlet and outlet elevations need to be set that depth below the channel flowline. After the culvert is analyzed, the culvert cross section can be viewed to confirm the culvert is modeled correctly by selecting the culvert under the crossing in the HY-8 Project Explorer.
- Culvert length is specified by the inlet and outlet stations. Typically the inlet station is set to 0.0 ft and the outlet station is the culvert length. This length is from where the top of the pipe daylights.
- Number of barrels will be set for each of the selected culverts (Section 10.3.3.4). Hit the "Add Culvert" button if the crossing requires multiple pipe with different sizes or properties. Examples might include adding a pipe next to an existing pipe or countersinking only one pipe of a multiple pipe crossing. After the culvert is analyzed, the front view at the inlet can be viewed to help show the differences of multiple pipe by selecting the crossing in the HY-8 Project Explorer.

Design Criteria: (Section 10.3)

Allowable Headwater: (Section 10.3.2.1)

- Determine which constraints and item establish the allowable design headwater as listed in section 10.3.2.1.
- Document what item is controlling the allowable headwater along with it's elevation and the resulting allowable headwater depth from the proposed culvert inlet flowline elevation.
- Intersecting road and approach culverts should be designed to meet the requirements of the adjacent mainline highway at the highway's design storm frequency in addition to meeting the intersecting road and approach requirements (Figure 7.6-A).

Outlet Protection: (Sections 10.3.2.6, 10.3.4.2 and 10.4.6)

- Provide culvert outlet protection based on culvert outlet velocity and guidance in Section 10.4.6.

HY8 Analysis and Results:

- After the above HY8 input data has been entered, hit the Analyze Crossing button. A Summary of Flows at Crossing window will open with Display options available to toggle.
- Crossing Summary Table display provides the overtopping discharge and flows through the culvert and over the roadway with the resulting headwater elevations. Example of this exported report is Exhibit 4A.
- Culvert Summary Table display provides a full summary of the culvert's flow, headwater, tailwater and velocity. Example of this exported report is Exhibit 4B.
- Review either or both of the above two summary table displays and then adjust the culvert size as needed until the allowable headwater design criteria is met. Return to the input data by hitting the Edit Input Data.. button. Compare proposed culvert size with the existing culvert size and verify if the size is reasonable.
- When the culvert size is obtained, export both of the above 2 summary table displays for each culvert. Name the Crossing Summary Table to "STATIONovertopping.pdf" and name the Culvert Summary Table to "STATIONresults.pdf" and place under U:\rd\prj\PCN#\drainage\.

Crossing Summary Table: (Exhibit 3)

The overtopping flow and elevation from this table will be used and documented according to Section 10.4.7 for final use on the plan/profile sheets. The overtopping year will be determined according to Section 10.4.7.

Culvert Summary Table: (Exhibit 4)

- Ensure the headwater elevation at the design discharge is at or below the allowable headwater elevation.
- Results show both inlet control and outlet control headwater depths. The highest depth between these two is used to determine the headwater elevation and indicates the type of control the culvert is in (Sections 10.4.3 thru 10.4.6 and 10.4.8).
- Culvert outlet velocity at the design discharge is used to determine the need for outlet protection as discussed above. The culvert outlet depth, tailwater depth and tailwater velocity results can also be used for consideration in the determination for outlet protection.

Documentation:

- Culvert Design Form for each culvert. Use to document HY8 input data, design criteria, methods used, recommendations and reasons for the design decisions (Section 6.5.2). Example forms are Figure 10.10-T or Exhibit 5. An electronic file of this form should be saved under U:\rd\prj\PCN#\drainage\.
- HY8 output results documented for each culvert as discussed above and examples in Exhibits 4A & 4B.
- Overtopping results should be summarized and documented according to Section 10.4.7.
- Special reports and recommendations may be written and provided to other offices as needed, such as culvert lining projects.

Thrust Blocks for Downspouts: (Section 10.3.3.9)

- Broken-back culverts/downspouts that require thrust blocks on the elbows/bends should be determined by the guidance at U:\rd\Doc\WorkFlowDocs\Thrust Block Analysis for Downspout.docx.

Exhibit 1 - HY-8 Software Main Window & Crossing Data Window

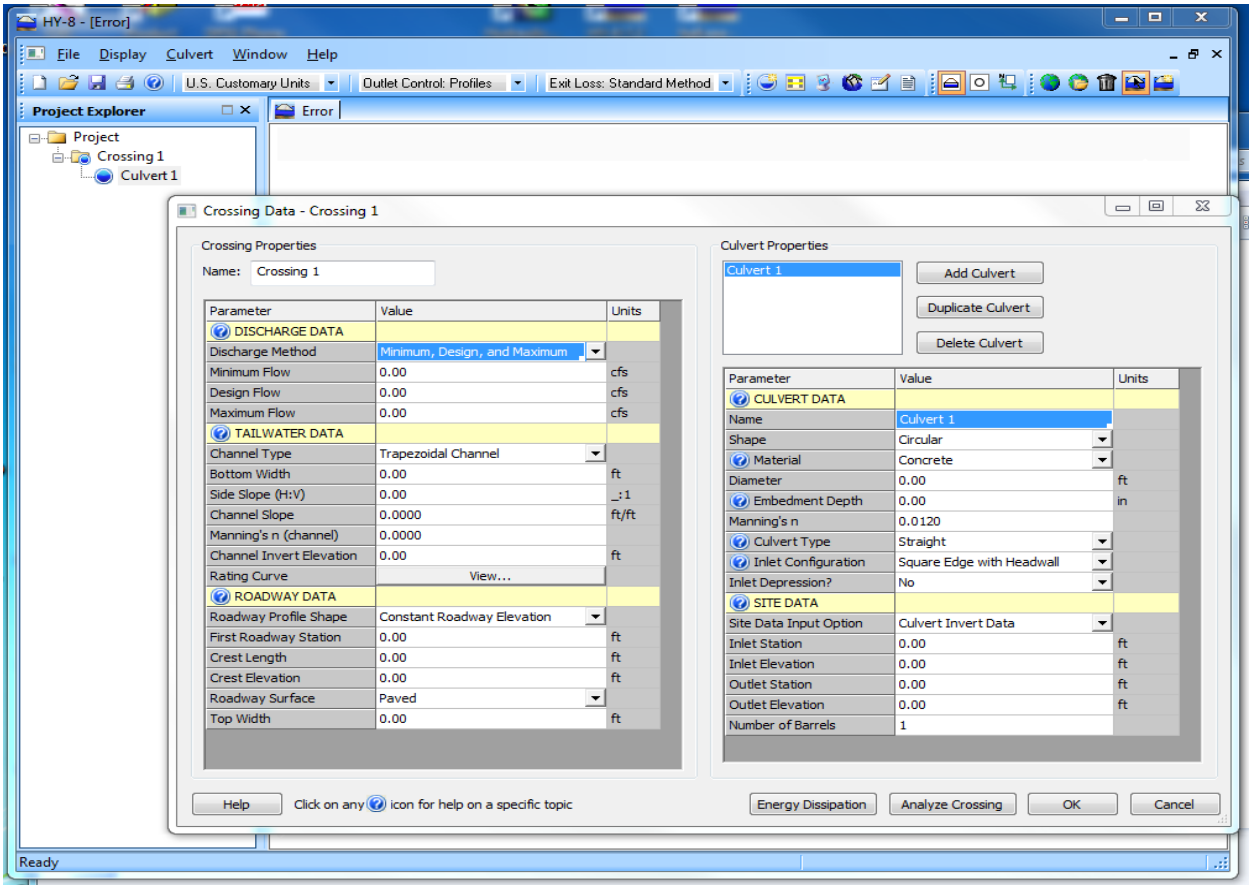
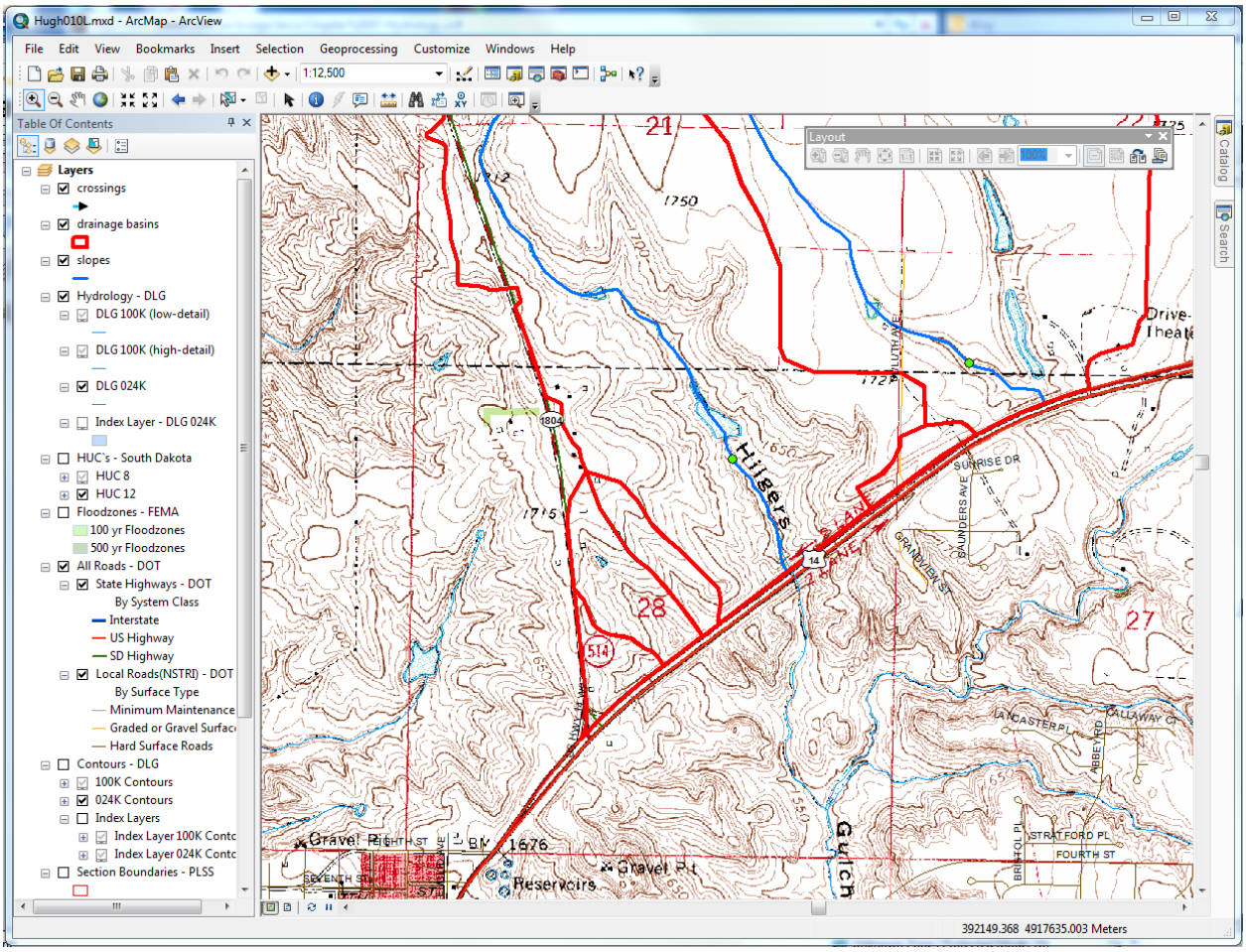


Exhibit 2 – ArcMap view with drainage basins layer shown as provided by the Bridge Hydraulics office



To show the drainage basins in ArcMap the following may need to be done. Toggle on the drainage basins layer. A Set Data Source window will open. Select drainage basins and hit Add.

Use the measure tool  to measure distances in ArcMap. Ensure the measurements are in the correct units.

Ensure the ArcMap file is set to the correct coordinate system by measuring the distance of a section line. Have Bridge Hydraulics Office correct the file if it does not measure correctly.

Exhibit 3A – Runoff Coeffients (C) for the Rational Equation.
These are in addition to those found in Figure 7.13-A of the SD Drainage Manual.
(Source: NDDOT Urban Storm Drainage)

Type of drainage area	Runoff Coefficients (C)
Roadway Ditches	0.20 – 0.50
Forested Areas	0.10 – 0.30
Meadows	0.10 – 0.40
Pasture Land	0.20 – 0.45
Cultivated Land, Sand and Gravel:	
Flat (<2%)	0.20 – 0.30
Average (2-7%)	0.30 – 0.35
Steep (>7%)	0.35 – 0.45
Cultivated Land, Clay and Loam:	
Flat (<2%)	0.30 – 0.45
Average (2-7%)	0.45 – 0.55
Steep (>7%)	0.55 – 0.70

Note: For the above ranges of values, use the lower values for flat slopes, permeable soils and dense vegetation and use the higher values for steep slopes, impermeable soils and sparse vegetation.

Exhibit 3B – Manning's n-values for Small Natural Stream Channels.
Surface width at flood stage less than 100 ft.
(Source: FHWA Manual HDS 5, Hydraulic Design of Highway Culverts)

	n-values
1. Fairly regular section:	
a. Some grass and weeds, little or no brush	0.030 - 0.035
b. Dense growth of weeds, depth of flow materially greater than weed height	0.035 - 0.05
c. Some weeds, light brush on banks	0.035 - 0.05
d. Some weeds, heavy brush on banks	0.05 - 0.07
e. Some weeds, dense willows on banks	0.06 - 0.08
f. For trees within channel, with branches submerged at high stage, increase all above values by	0.01 - 0.02
2. Irregular sections, with pools, slight channel meander; increase values given above about	0.01 - 0.02
3. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged aat high stage:	
a. Bottom of gravel, cobbles, and few boulders	0.04 - 0.05
b. Bottom of cobbles, with large boulders	0.05 - 0.07

Exhibit 4A – HY8 Crossing Summary Table Report used for the overtopping flow information

HY-8 Analysis Results

Crossing Summary Table

Culvert Crossing: 69+85

Headwater Elevation (ft)	Total Discharge (cfs)	30"RCP Discharge (cfs)	Roadway Discharge (cfs)	Iterations
2904.10	0.00	0.00	0.00	1
2904.91	3.10	3.10	0.00	1
2905.28	6.20	6.20	0.00	1
2905.58	9.30	9.30	0.00	1
2905.84	12.40	12.40	0.00	1
2906.08	15.50	15.50	0.00	1
2906.33	18.60	18.60	0.00	1
2906.60	21.70	21.70	0.00	1
2906.82	24.00	24.00	0.00	1
2907.25	27.90	27.90	0.00	1
2907.47	31.00	29.71	1.23	13
2907.30	28.34	28.34	0.00	Overtopping

Exhibit 4B – HY8 Culvert Summary Table Report

HY-8 Analysis Results

Culvert Summary Table - 30"RCP

Culvert Crossing: 69+85

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	2904.10	0.00	0.0*	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
3.10	3.10	2904.91	0.81	0.0*	1-S2n	0.48	0.57	0.48	0.22	4.67	0.78
6.20	6.20	2905.28	1.18	0.0*	1-S2n	0.67	0.82	0.68	0.28	5.74	1.00
9.30	9.30	2905.58	1.48	0.0*	1-S2n	0.83	1.02	0.84	0.34	6.39	1.15
12.40	12.40	2905.84	1.74	0.0*	1-S2n	0.98	1.18	0.98	0.38	6.94	1.26
15.50	15.50	2906.08	1.98	0.0*	1-S2n	1.11	1.32	1.11	0.42	7.32	1.36
18.60	18.60	2906.33	2.23	0.0*	1-S2n	1.23	1.46	1.23	0.46	7.73	1.44
21.70	21.70	2906.60	2.50	0.0*	5-S2n	1.35	1.58	1.35	0.49	8.02	1.51
24.00	24.00	2906.82	2.72	0.0*	5-S2n	1.44	1.66	1.44	0.51	8.19	1.56
27.90	27.90	2907.25	3.15	0.0*	5-S2n	1.59	1.80	1.59	0.55	8.48	1.64
31.00	29.71	2907.47	3.37	0.0*	5-S2n	1.66	1.85	1.66	0.58	8.57	1.69

Exhibit 5 – Culvert Design Form Example

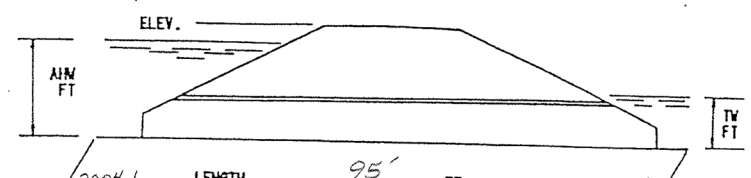
HYDRAULIC ANALYSIS OF CULVERTS

PROJECT: 02AB
STATION: 69+85

DESIGNED: ~~JAK~~
DATE: 12-15-11

DRAINAGE AREA 27 ACRES
DRAINAGE AREA 0.042 SQ. MILES (A)

Design Frequency = 25 yr



Existing = 30" RCP
@ 67+74

Existing = 2904.21

Existing = 2903.56

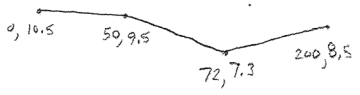
Discharges: USGS Subregion F eqn. - NA
use Rational - see spreadsheet

t_c = 30 min. Q = ciA

i_{10} = 2.9 Q_{10} = .25(2.9)27 = 20 cfs
i_{25} = 3.6 Q_{25} = .25(3.6)27 = 24 ←
i_{100} = 4.6 Q_{100} = .25(4.6)27 = 31

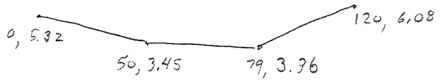
Allow Hw: Hwy Low Subgrade @ 70+50-R = 2907.94
one foot below subgrade − 1
2906.94
2904.1
Allw$_{25}$ = 2.84'

Overtopping: Entrance @ 70+66-R = 2907.3
2904.1
OT = 3.2'



- Move culvert to low outlet channel location.
- Use entrance at 70+66-R as ditch block.

Tailwater:



Tw slope = (3.36 − 2.87) / 86.0' = 0.0057 ft/ft

Results:

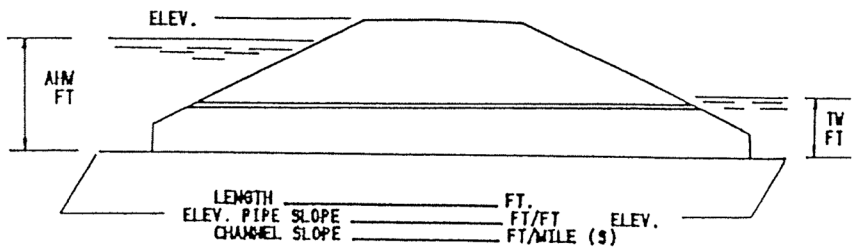
	Q0T	HW25	V25
→ 30" RCP	28.3 cfs	2.72'	8.2 fps < 10 No Gabions
No 24" RCP	19.7	3.44'	7.6

HYDRAULIC ANALYSIS OF CULVERTS

DESIGNED:
DATE:

PROJECT:
STATION:

DRAINAGE AREA _____ ACRES
DRAINAGE AREA _____ SQ. MILES (A)



PathView Videolog Workflow

Double click on the "**Videolog**" icon on your desktop

Enter your Citrix Password when prompted

Click "**NO**" when asked if you want to **Load Previous DB?**

Under **File** –click **Open Road Section File**

- The first time you do this, you will have to use the Down Arrow next to the Look in: box and choose Videolog2$ on 'Espr1fs12'(R:) as all the road section files are on the R: Drive

- Under the R: Drive, choose the 2011XP folder

- Scroll past the numbered folders to the .sec files and choose your Region:
  1_Region.sec = Aberdeen Region
  2_Region.sec = Mitchell Region
  3_Region.sec = Pierre Region
  4_Region.sec = Rapid City Region

- The next time you go to Open Road Section File, it should automatically put you in the 2011XP folder on the R: Drive

Click "**NO**" when prompted to Use Filters. (It will take about 1 minute to load all records)

Under **Image**-click **Digitized Image Control**
You can now select the Road and MRM you want.

HINTS:

- Use the mouse and left click the arrow button on the Digitized Image Control window to move one image at a time. Press and hold left mouse button for fast scroll. Right click to drive along the highway.

- The Skip feature allows you to advance at variable intervals. In the Image control box there is a box labeled Skip. You can enter the distance in feet that you want to use and each time you click the mouse it will advance that distance, so that you can travel forward or backward faster. When the program is set to advance automatically it will also advance automatically at the distance that you have set. When you want return to travel at the usual rate, just change the distance back to zero.

- If you have any questions or need help call John Whaley at 773-3607

Also available is StreetView which is part of Google Map. http://maps.google.com/. This is a free service provided by Google. Remember that computers are for **work related** use. Please don't misuse them. It is very easy to use and has an instructional video http://maps.google.com/help/maps/tour/#street_view

7.5 Minute Quadrangles referenced into MicroStation Files.

Need to know:

- The Latitude/Longitude of the project.
- State Plane Coordinate(SPC) Zone for the project.
    - The Zone for each county is listed in the CADD Procedures Manual, Section A – General, page A8 .

Open your DGN.

Set the Geographic Coordinate System

Tools > Geographic > Select Geographics Coordinate System

Geographic Coordinate System > From Library (SD83-NF or SD83-SF)

Attach as a reference the DGN with the Quadrangles attached. Using the

Attachment Method: Geographic - Reprojected

- Location U:\rd\Misc\Maps\Quadrangles\
- File Name will match LAT/LONG.

Note: Recommend Clipping this reference file.

Other information to reference into your DGN

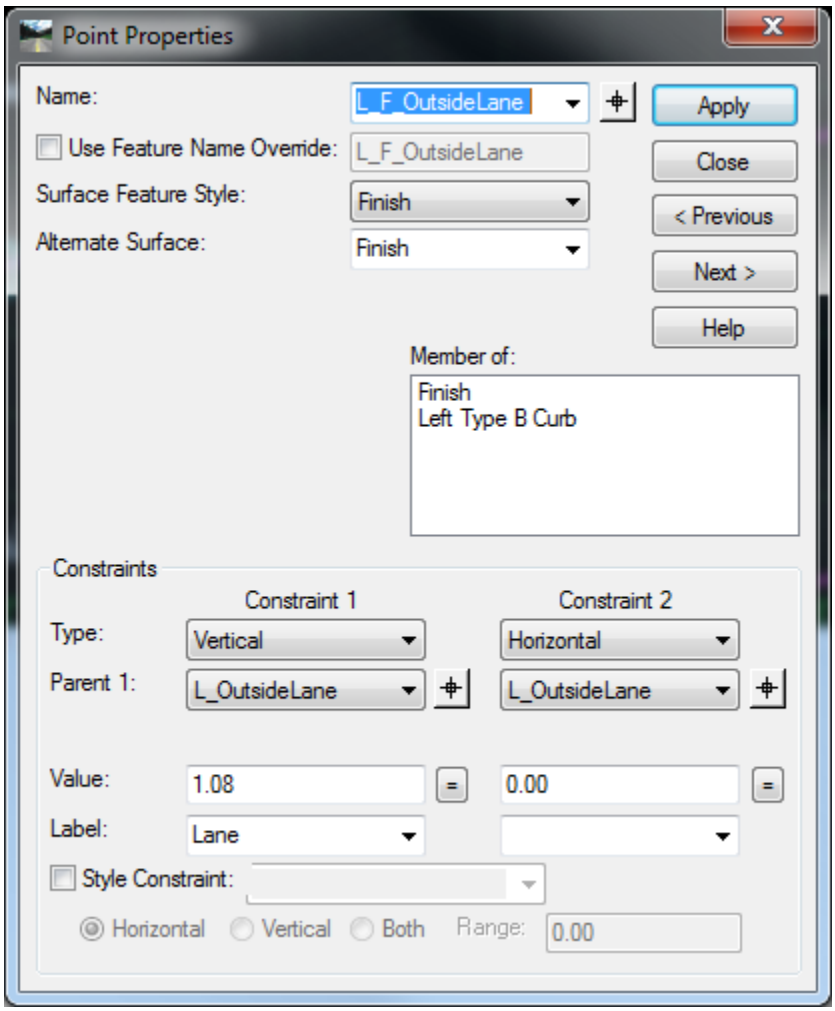
- MRM U:\rd\Misc\GIS\ShapeFiles\MRM\MRM.shp
- Wetlands, Hydraulic Drainage Areas and Archeological sites found project specific

Creating Alternate Surface

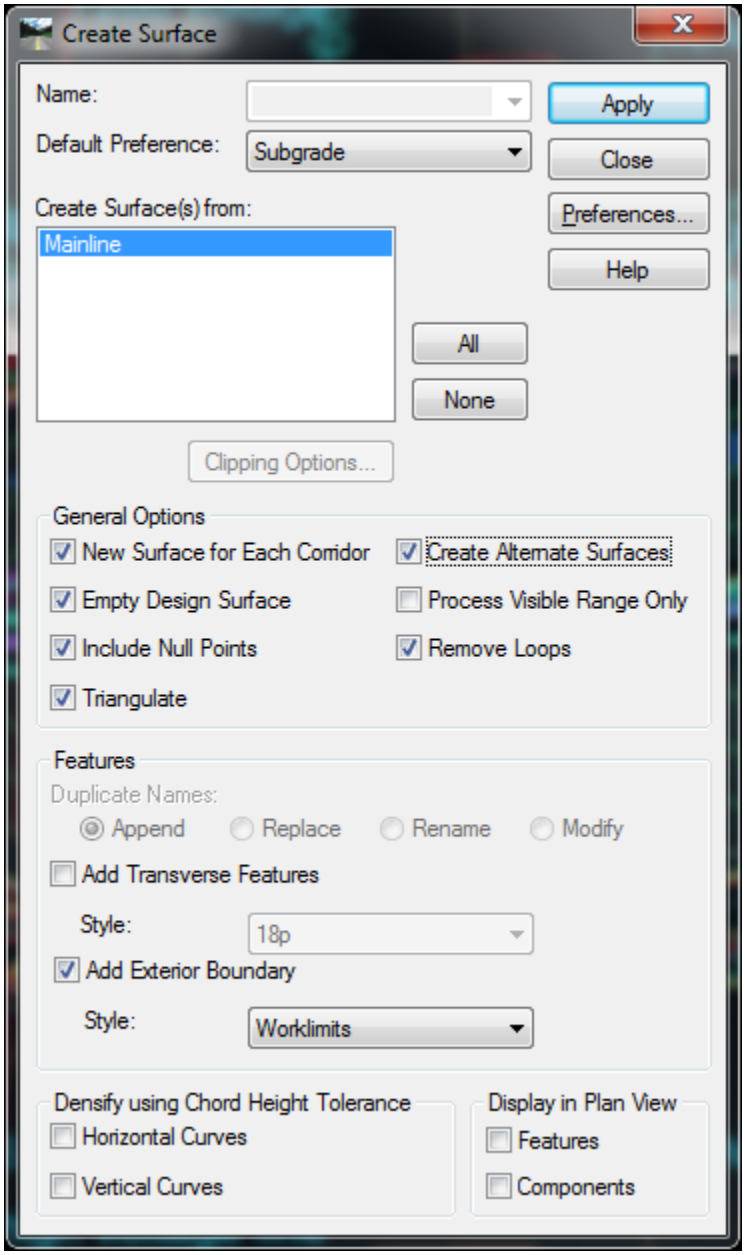
To create a dtm surface of the proposed finish surface along with the subgrade surface that is normally created, an alternate surface may be created. This may be helpful in annotating the centerline point of the finished surface using the 10_20 or 20_40 scale preferences rather than just the centerline point of the subgrade surface. Another useful aspect of the alternate surface is that the designer can display either contours or triangles of the finished surface to use for urban grading. It is a quick and easy way to see what the actual finished elevations will be without having to add the surfacing thickness to the subgrade.

To create an alternate surface:

- Select **Modeler <Create Template** or Inside the Roadway Designer, Select the "Open Template Library" Button 
- Once inside the template library for your project, double click on a template that is going to be used on the project.
- Select a point to edit along the finished surface component that you would like to include in the new alternate surface. A good point to start with for editing would be the left outside lane point. Double click the point or **Right Click < Edit Point…**
- Next to **Alternate Surface:** Type in the name of the alternate surface that you would like to call it. For this example you would name it Finish as shown below. Also, you will want to give it a **Surface Feature Style:** The "Finish" style is a good one to use.



- Once you have typed in the name of the surface, click <<Apply>>. Repeat this process for the other points you wish to include in the alternate surface by using the drop down and selecting the surface name that you entered for your first point.
- Repeat this process for the other templates used for the project making sure to use the same alternate surface name.
- Save template library.
- Make sure to go to **Corridor < Template Drops…** and synchronize your Template Library changes that you just made.
- Select **Corridor < Create Surface…** or select the "Create Surfaces" Button 
- In the Create Surface dialog box turn on the "Create Alternate Surfaces" check box. Select <<Apply>>.



- Your new surface will be created. By default the regular surface created will be the same as the Corridor name which is Mainline in this case. The alternate surface will be named Mainline – Finish in this case or whatever you had named your alternate surface.
- Save the newly created surface for future use.